Projecte de Fi de Carrera

Enginyer Industrial

Process set up and technology improvement of a cutting and aplication unit of disposable tape

MEMÒRIA

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Curs acadèmic: 2010-2011

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Summary

This final thesis report gathers the process set up and technology improvement of a cutting and application unit of disposable tape.

All this work is realized in collaboration with the company Fameccanica.Data S.p.A., located in Via Aterno 98, Sambuceto di Teatino, Italy.

This unit in particular is a part of a production line of baby diapers. Till now this unit is used to apply patches of disposable tape at 500ppm (pieces per minute).

The tests goal is to reach a defined application speed of 1000ppm. Is the first one of this kind of units in the world that it reaches that speed.

In order to study the way to speed up the unit, we acquired all the relevant data for each process speed. We started doing an analysis without raw material of the vibration of the unit making short time acquirements (10 seconds each acquirement of data) for each velocity (from 100ppm to 1000ppm in intervals of 100ppm) and then making a dry run long time analysis (6 hours to analyze the stationary behavior of all the relevant variables). During the tests we have observed the temperature trend of the critical components (Thermical analysis), the noise and the motor torque trend of the unit and its vibration behavior in each velocity in order to check if all it is ok to speed up the unit.

The results that we obtained have shown us that the temperature, torque and noise trends are correct in the new velocity without problems. The vibration produced by the rotation cuts in the chosen position of the counter-weight is a little bit high, but it can be assumed by the unit in the production process without problems. We choose the position that minimizes the vibration effect analyzing the acquired data.

When we have finished these analyses and we have chosen the right way to work with the unit at 1000ppm, we started analyzing the product results with raw material with the unit assembled in the test bench (that we have assembled in 3D CAD format first) in order to check if the real process is working correctly at the scope velocity in the real application and to design the improvement kit for the unit to reach our goals.

The conclusion of all this study is that is very necessary to do an accurate study of viability of the relevant variables in any upgrade that you want to perform in a unit or machine in order to do it correctly before the real testing process, and test it correctly in a bench test to see it in its real application to check if any improvement kit is needed. I also noticed the importance of the R&D work in the technology growing of a company. It can be summed up as “nonstop innovation”, like the Fameccanica.Data slogan.

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1. Introduction

1.1. Objectives of the project

The objectives of the project are

1- Define on the standard technology/process of the reference quality at 500 pieces of disposable tape per minute (ppm).
2- Measure quality and performance of the same technology/process at different process speed up to 1000 ppm defining the relevant variables of the process.
3- Design the improvement kit in order to guarantee quality and reliability at least 800 ppm if it's necessary.

In order to achieve all this objectives we have to perform different analysis to reach our goals.

It's a mix of theoretical and practical work, acquire data, study data and analyze the results in a real work. The correctly interpretation of the results is very important to not miss any detail that could make us fail in our objectives.

1.2. Scope of the project

The scope of the project is to implement this speed up in that rotational cutting unit to upgrade all the production lines that contain, or has to contain in the future, this unit.

The scope is very ambitious because is the first unit of this kind in the world that reaches that cutting and application speed of 1000ppm (500rpm).

1.3. Motivation to do this project

Is a very interesting project to understand the way of working of a Research & Development department in a big company, because it gathers developing work to design and project the assembly of the unit in the test bench, and research work in order to understand and analyze all the relevant variables in the rotational cutting and application.

Is also a great opportunity to see and understand the behavior of a real big company from inside working there.

2. The company Fameccanica.Data S.p.A.

Fameccanica.Data company is placed in Sambuceto di S.Giovanni Teatino (CH). In the region of Abruzzo, Italy.

Fameccanica is the leading equipment supplier for the hygienic disposable absorbent converting industry worldwide. Fameccanica's secret to success is state-of-the-art technology, continuous innovation and the ability to work in partnership with clients and suppliers.

Since 1975, Fameccanica has been steadily expanding its growth-trend and today the company boasts status as an International Group.

Figure 2.1 Photography of the entrance area of the R&D plant of Fameccanica.Data S.p.A. company

The Fameccanica Group is innovative when it comes to designing and manufacturing of machines. A high degree of specialization is crucial for innovative manufacturing of disposable sanitary converting machinery.

In the lady sanpro, baby and adult incontinence diapers sector Fameccanica represents outstanding innovation.

Fameccanica believes in excellence when it comes to output and performance. The company's machines are flexible, efficient and extremely reliable.

The foundation of Fameccanica was immediately accompanied by a far-sighted vision: to become a leading company in its market and expand at international level.

Nowadays, the Fameccanica Group is a reality and can rely on four companies: Fameccanica.Data in Italy, centre of excellence and key point of reference, Fameccanica Machinery Shanghai, Fameccanica do Brasil and Fameccanica North America. A strategy that allows Fameccanica to be close to its clients not just logistically but also culturally, with a system of relations that overcomes barriers, making the most of local resources while maintaining a central coordination of its projects.

Figure 2.2 Fameccanica logo

The ability to manage the platforms, models and arrangements is the key element with which Fameccanica manages to fully satisfy the specific needs of a wide range of clients, with perfectly adequate solutions that are simultaneously, highly competitive. Today, more than ever, Fameccanica can anticipate the needs of its clients and market trends and offer advanced technological solutions and high performance standards that ensure that their clients can operate with excellent results.

Fameccanica works daily to provide maximum satisfaction. This is why it set up a global organization and a series of services that revolve around you and guarantee reliability, safety and tranquility.

Fameccanica, Non stop innovation.

3. The unit

3.1. Working of the unit

The unit that we are going to speed up is a part of a line machine that produces baby diapers. This unit in particular cuts and applies the disposable tape (to close the diaper when it is used) to the finished diaper.

Is a rotation cut and application machine and its physical characteristics are:

Weight: 430 Kg

Dimensions: 60x90x45 cm

The revolution alimentation of the unit to do the firsts tests without raw material is given by a synchronous servomotor Bosch Rexroth MSK071E-0300 (technical data in Annex A) who gives power to the reduction transmission 90-30 (reduction ratio equal to 3) that moves the transmission tree as we can see in figure 3.1.1 to rotate the cutting zone.

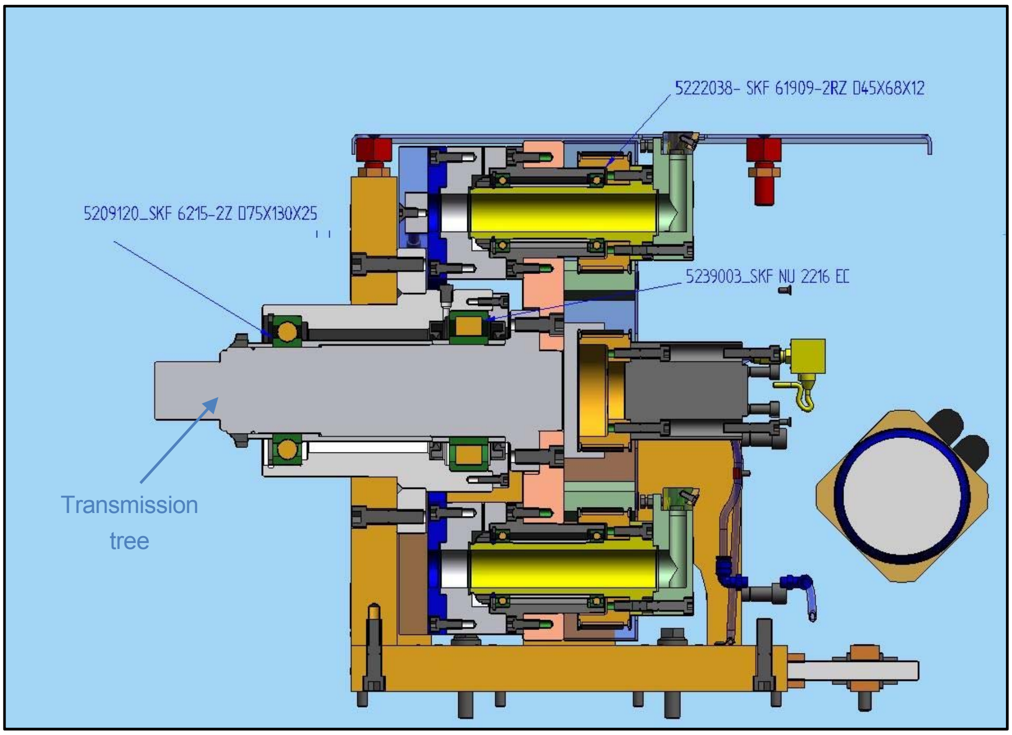


Figure 3.1.1 Section view of the unit, transmission tree and bearings with their codification

The cutting zone, the part where we focused all the study, is composed by a principal plate or table who contains the two knives and the counterweight to balance the acceleration inertia produced by the rotation, as we can see in the figure 3.1.2. The cutting unit type is two up because in each rotation it makes two cuts, one for each knife.

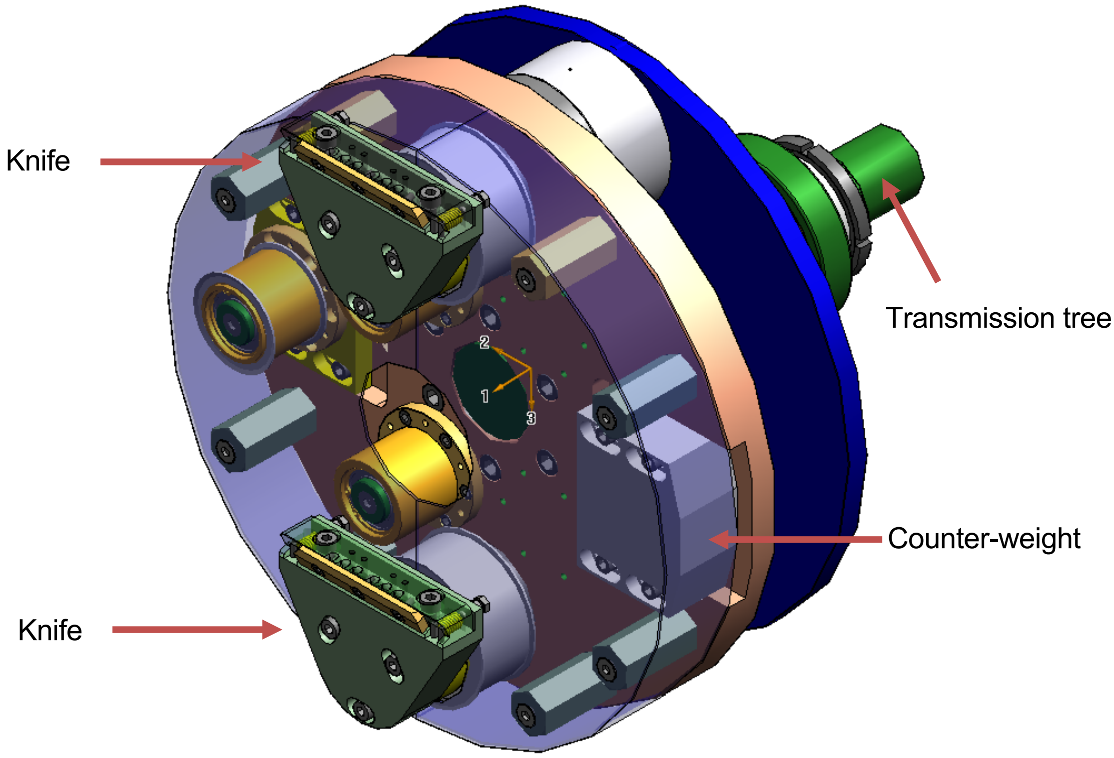


Figure 3.1.2 Solid Edge image (3D CAD) of the cutting zone of the unit

The cut is produced by the interference between the two rotating knives and the fixed one. The knife material is tungsten carbide because it performs an accurate and very good finished cut that we need to make in this unit. (We talk more about this material in the next sub-chapter).

The alimentation of the disposable tape and its application to the product is realized in cross direction, at 90º, respect of the production direction of the machine. The disposable tape enters into the unit prepared and ready to be cut at the correct measure and applied. It enters like a finished product to be assembled into our diaper.

The disposable tape arrives to the fixed knife, shown in the Fig. 3.1.3, by a conveyor who transports it into the cutting zone. The active part is the rotating one and in which we want to make the speed up.

The rotating knife keeps horizontal respect to the floor plane in each moment of the rotation in order to make a clean cut and to apply correctly the disposable tape to the diaper.

To perform a good cut produced by the interference between the two knives it's important to have the fixed knife refrigerated to keep it clean from the glue of the disposable tape, but it cannot be refrigerated directly because the tungsten carbide physical properties.

For that reason it has to be refrigerated by heat transmission through its support by a chiller with Glycol as refrigerant.

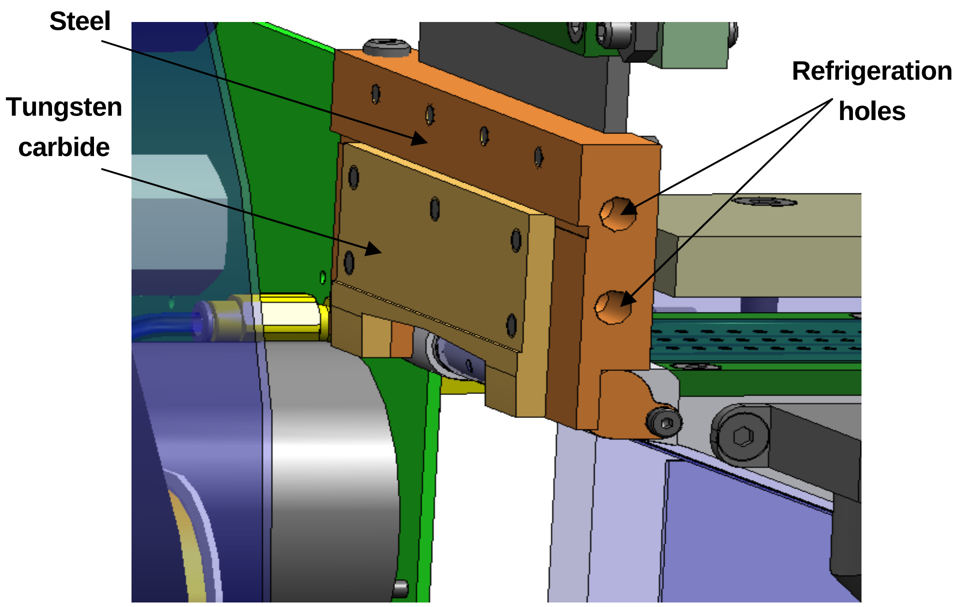


Figure 3.1.3 Solid Edge image (3D CAD) of the fixed knife and its support with refrigeration holes

The rotation knife also has a vacuum system, shown in the Fig. 3.1.4, to catch the disposable tape when it is cut and to not allow moving it obtaining an optimum application to the diaper.

This vacuum system only works in the path where the knife has the disposable tape on it till it arrives at the diaper; in the rest of the rotation path it doesn't works.

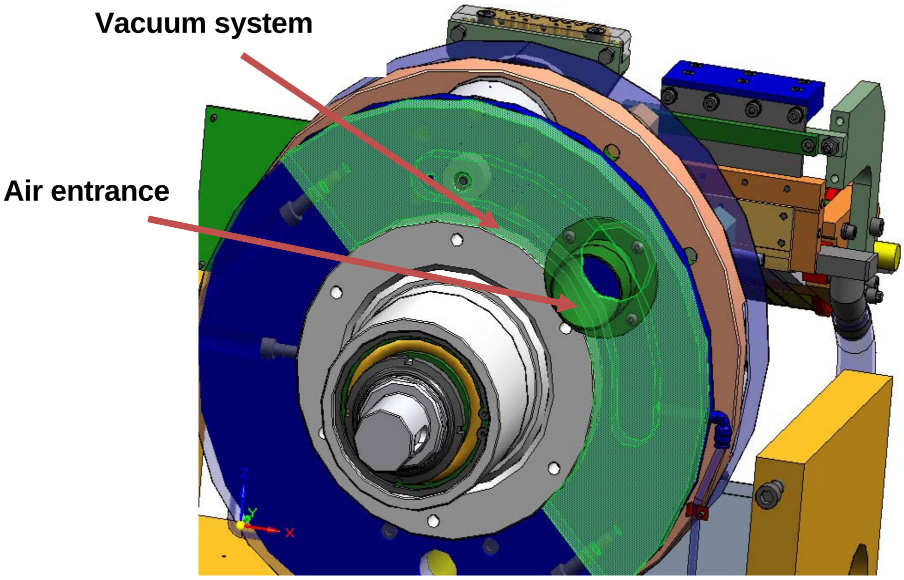


Figure 3.1.4 Solid Edge image (3D CAD) of the vacuum system

3.1.1. Tungsten Carbide, the knives material

Tungsten carbide is approximately three times stiffer than steel, with a Young's modulus of approximately 550 GPa, and is much denser than steel or titanium. It is comparable with corundum (α-Al_2O_3 or sapphire) in hardness (8.5-9.0 Mohs scale, Vickers hardness number 2242) and can only be polished and finished with abrasives of superior hardness such as silicon carbide, cubic boron nitride and diamond amongst others, in the form of powder, wheels and compounds. [5]

Carbide cutting surfaces are often used for machining through materials such as carbon steel or stainless steel, as well as in situations where other tools would wear away, such as high-quantity production runs. Carbide generally produces a better finish on the part, and allows faster machining. Exactly what are we looking for with our cut of disposable tape.

Carbide tools can also withstand higher temperatures than standard high speed steel tools. The material is usually called cemented carbide, hardmetal or tungsten-carbide cobalt: it is a metal matrix composite where tungsten carbide particles are the aggregate and metallic cobalt serves as the matrix. [6]

3.2. Rotational inertia check

In order to choose the correct motor for our analysis we have to calculate our unit inertia. We have to perform an inertia calculus of the rotating parts of our unit to check if the motor used for the first analyses (without raw material and without vacuum system) has enough torque to do it correctly.

The Solid Edge program calculates the equivalent rotating inertia for us if we select the material of each part involved in the rotation of the unit.

Out of the program we have to calculate the reduced inertia, as is shown in the equation 3.2.1, of all the parts of our rotating plate, shown in the figure 3.2.2, and of our knives. All the calculus are made and explained in the Annex A.

$$J_{reduced} = \frac{J_{equivalent}}{(\frac{r_{reduction}}{r_{pulley}})^2} \quad [Kg \cdot m^2]$$

Equation 3.2.1 Calculus of Reduced Inertia, where:

J = Inertia, r = ratio of transmission

We calculate the equivalent and the reduced inertia of the plate with the counterweight and the two rotating knives, and the reduced inertia of the entire unit is the sum of all these three reduced inertias.

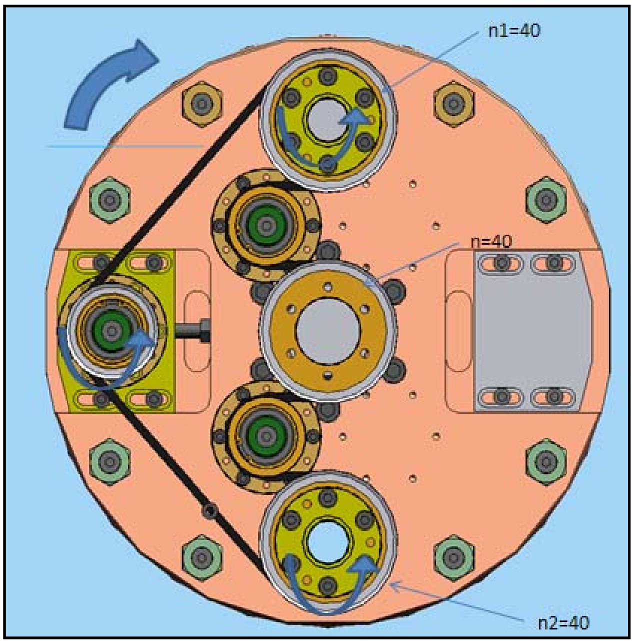


Figure 3.2.2 Rotation direction of the elements of the rotating table or plate of the unit

The resulting reduced inertia is $1{,}933526\ \mathrm{Kg \cdot m^2}$, and we have to calculate an inertia ratio between this resulting inertia and the moment of inertia of the motor without brake.

This moment is $0{,}0029\ Kg \cdot m^2$ and it appears in the technical specifications of the motor in the Annex A, and the inertia check ratio is $74{,}08147$, calculated by the equation 3.2.3

$$r_{inertia\ check} = \frac{J_{resulting\ reduced}}{J_{motor\ without\ brake}}$$

Equation 3.2.3 Calculus of inertia check ratio

The result is pretty high. This could mean that now, without friction of the raw material and without the vacuum system, we don't have any kind of problem, but it could appear when we do the analysis with row material and vacuum system.

In order to solve this possible problem, we use a higher motor, that we have in the Fameccanica.Data warehouse, when we realize the analysis on the test bench, Bosch Rexroth MSK 100C-0300 M1, a multi turn motor with a moment of inertia without brake of $0{,}011\ Kg \cdot m^2$ having a inertia check ratio of $19{,}53$, lower than 25, the optimum result.

4. Vibration analysis

4.1. Introduction

Before to start the study of the relevant variables of the process we have to choose first the better position of the counter-weight, as is shown in the figure 4.1.1, to minimize the vibration produced by the rotation and the cuts of the unit. Is the only piece of the rotating table that we can modify its position, because the other pieces cannot be moved in any direction.

The counter-weight is a stainless steel piece of 3,7 Kg.

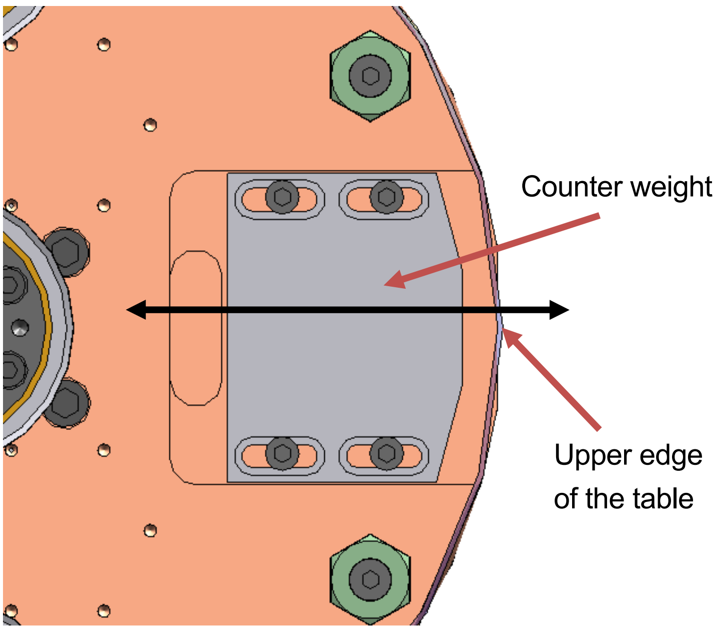


Figure 4.1.1 Solid Edge image (3D CAD) of the counterweight positioned in the table.

The vibrations are produced by the oscillation of our rotating table with all the masses that where on it, because the table isn't balanced. All these vibrations are periodical (they are repeated for each rotation) and they are formed by different factors (different masses and positions).

For that reason we have multiharmonical vibrations that we have to measure and check in which counter-weight positions are lower the most relevant. To measure the contribution of each single harmonic it's necessary to do a frequency analysis in the time.

We are also interested to track the behavior of the vibration to see if the maximum values of acceleration produced by the vibration at our scope velocity are admissible and to check the periodical behavior of the unit's rotation.

To sum up we can see in the figure 4.1.1 what we want to do, measure the contribution of the vibration to see the maximum values and the acceleration trend, and analyze the frequencies induced by the different masses that are more relevant. We are in a similar case like the third example.

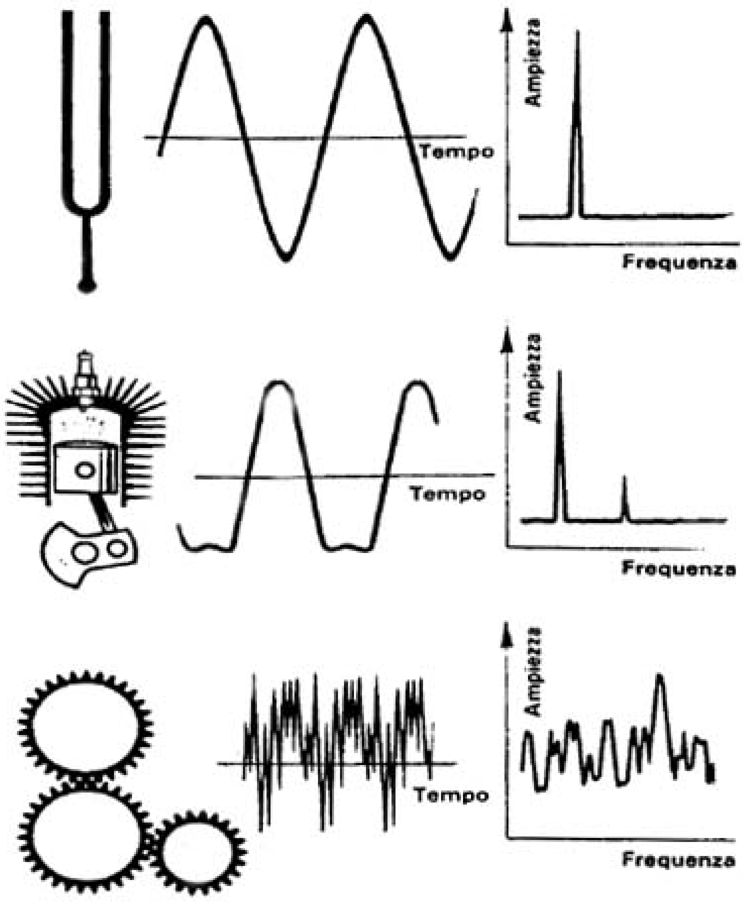


Figure 4.1.1 Vibration and frequency analyses examples [1]

4.2. Accelerometer and acquisition module

In order to acquire the acceleration data produced by the vibration to do the studies that we want to perform, we need a piezoelectric accelerometer.

A piezoelectric accelerometer is a small instrument, as we can see with our accelerometer in the figure 4.2.1, that can transform the mechanical deformation produced by the vibration of the mass where is it attached into a differential of voltage.

Figure 4.2.1 Photography of the triaxial accelerometer that we used

The piezoelectric crystal works like this: when it receives an external pressure in a face it places charges of opposite charge in the opposite face. If the two faces are connected to an external electrical circuit, these create a differential of voltage. [1]

The piezoelectric accelerometer also works in the opposite way; it can be deformed producing an external pressure if it receives an external differential of voltage. For that reason is very important to isolate electrically the instrument in order to avoid external voltage currents from the electric motor.

To measure the values of vibration in each direction is necessary to have a triaxial accelerometer, one acquisition channel for each tridimensional axis.

To acquire the vibration data of our unit we have to connect the piezoelectric accelerometer to an acquisition module (constituted by a pre-amplificator, a signal conditioner, an A/D converter and a signal analyzer) with an output to a computer, to record the values of that differential of voltage along the time produced by the vibration of the mass.

The accelerometer that we have used is a DYTRAN model 3023A2 miniature triaxial LIVM^{tm}. (Its technical characteristics sheet is in the Annex A), and the acquisition module is developed by RobotroniX.

4.3. Acquisition campaign

We have acquired all the data with the piezoelectric triaxial accelerometer placed in the same position, in the right of the frontal part of the unit.

Our acquisition campaign methodology has followed the next steps:

- Recording data in intervals of 10 seconds for each velocity, starting from 100ppm (50 rpm) to 1000ppm (500rpm) increasing each time 100ppm the rotational speed.
- Repeat this for each position of the counter-weight, as is shown in the figure 4.3.2. Each position is spaced 5mm from each other, starting at 5mm away from the upper edge in the high position till the 25mm away from the upper edge in the low position.

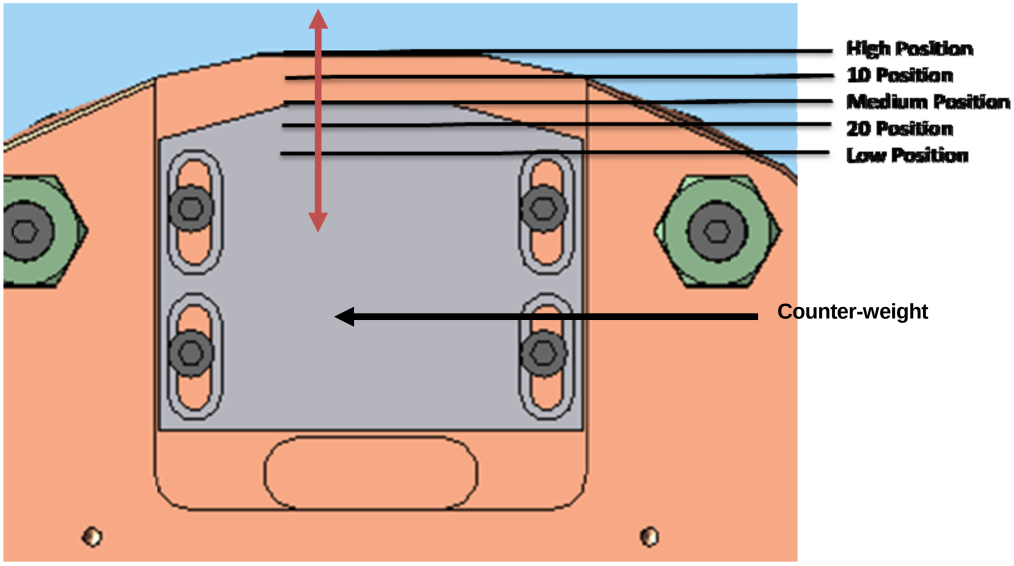


Figure 4.3.2 Position of the counter-weight related with this distance from the upper edge

When he have acquired all this data for each velocity and each position, we also have repeat the same steps but this time without knives, in order to obtain the vibration and acceleration produced by the revolution only, forgiving the effect that gives each cut in the vibration.

We have done this because the effect of the cut is much higher than the one produced by the rotation and this fact is not going to help us in the interpretation of the results.

Without the cut effect the results are much clear, but we also need the acceleration with the cuts in order to know if the maximum peaks are going to be supported or not in a long time running of the machine.

This decision is made after doing the first analysis with knives. We repeated the acquisition campaign without knives later. This is explained in the chapter 4.5.4.

To do all this acquisition campaign our accelerometer has been connected to an acquisition logger module, as is shown in the figure 4.3.3, that it acquired at 10 KHz and connected to a computer where we have recorded all the data into the files that we have used after to work with them.

We have all this values in Volts, because as we said before, the piezoelectric accelerometer creates voltage differential induced by the mechanical deformation produced by the vibration of the unit.

Figure 4.3.3 Acquisition logger module

To work after with all these data we only need to know from the technical characteristics accelerometer sheet the sensibility conversion of each axis to convert the differential of voltage (in Volts) to acceleration (in g).

4.4. Working with the acquired data

We acquired all the data with an acquisition software of National Instruments, Labview Signal Express, and the format of their files is .tdms. To work with the data we used a post analysis software, also from National Instruments, DIAdem. Interface shown in figure 4.4.1.

We use this program because in the frequency that we are acquiring, 10 KHz, and for the time that we are doing the record of the data, 10 seconds, we have 100000 points for each acquisition. That is the reason why we don’t use Microsoft Excel (Labview Signal Express can export the data to Microsoft Excel format also) to perform the graphics and work with the data, because Excel is limited to work as maximum with 33000 points, and we are working with the triple in each acquisition, and we made 10 for each position of the counter-weight.

We have worked and made all the data analysis separating the values for axis, by this way we have been able to compare for each axis (X,Y,Z) which one is the best counterweight position.

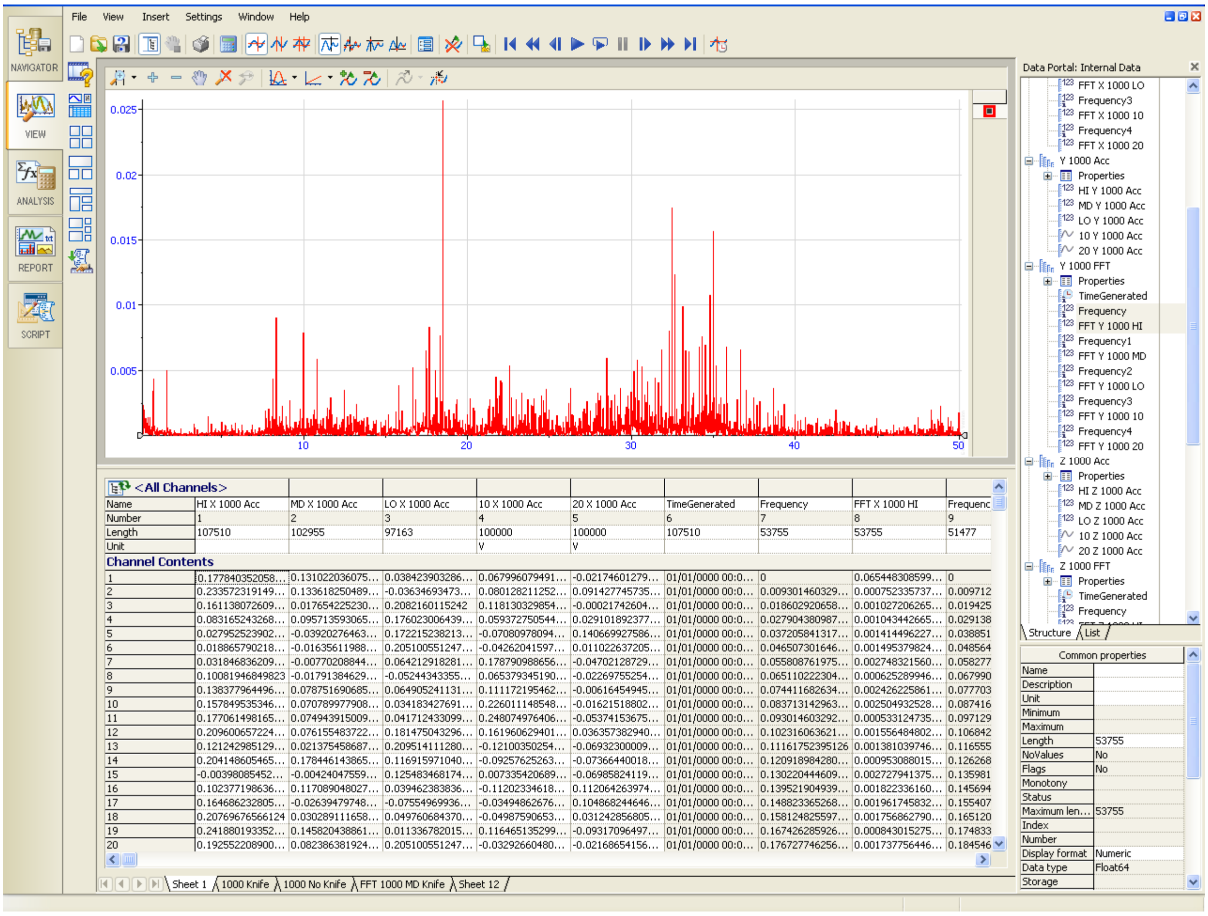


Figure 4.4.1 Working with National Instruments DIAdem post analysis software

4.5. Analyzing data. Results

4.5.1. Acceleration

In order to see the trend of the acceleration and its behavior with the cuts of the unit we have performed a graphic of the acceleration for each velocity in each counter-weight position.

For example, because the trend is the same for all the velocities and for all the positions, at high position and at 1000ppm we can see in the figure 4.5.1.1. that we have, as we have expected, a periodic trend for the vibration produced by the cuts.

These accelerations in g are so high, but it is possible to have these values in an instant produced by the interference of each cut.

This acceleration analysis doesn't give us much more relevant information for our study.

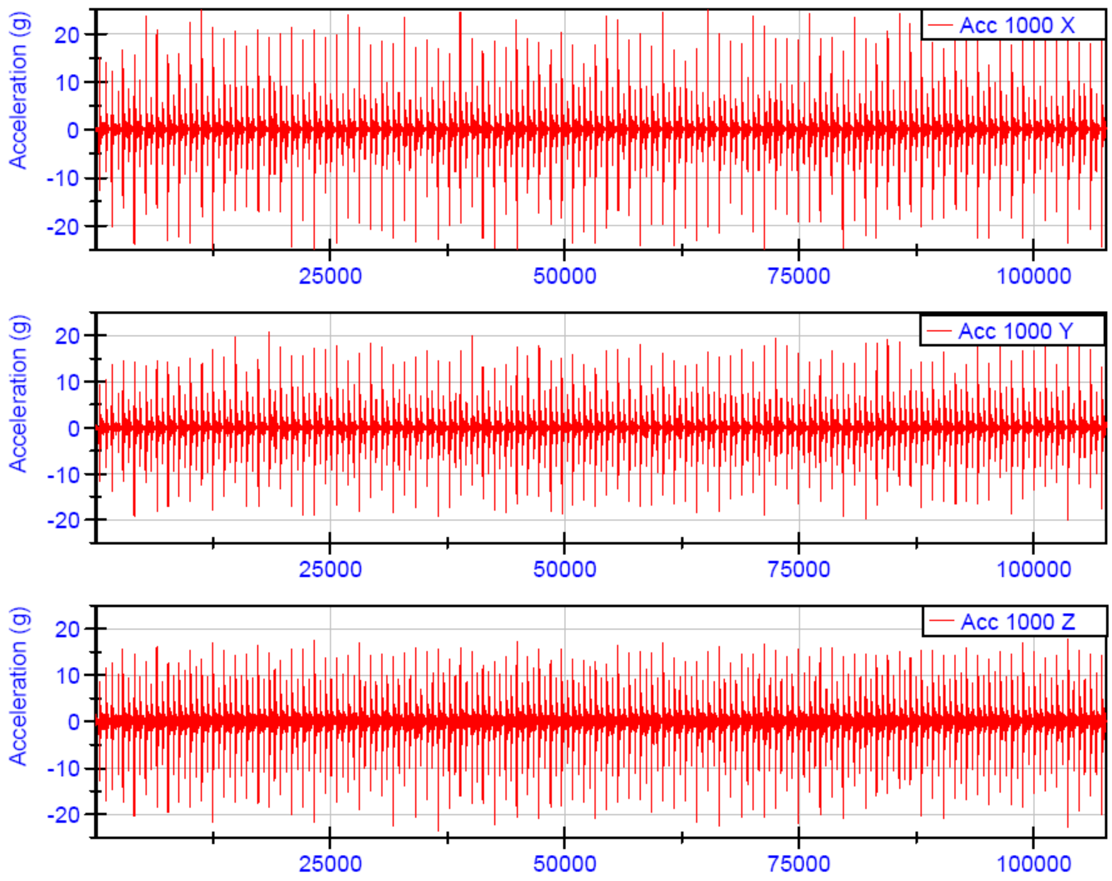


Figure 4.5.1.1 Acceleration for each axis at high position at 1000ppm

4.5.2. Maximum peaks of acceleration

It is also interesting to calculate the media of the maximum peaks for each velocity for each axis in order to see the trend of the maximum values if it is affected linearly for the speed up of the unit or not.

We have done this analysis only for three of the five positions of each axis, high, medium and low.

The X axis is the one that receives a higher value of maximum acceleration at 1000ppm. There are two interesting facts that we want to emphasize. We can see them in the figure 4.5.2.1.

The first one is that in X axis we have different magnitude values from Y axis although they are in the same plan of the unit. This happens because the unit doesn't have the same structure or the same resistance in these two axis.

The second one is that in 1000ppm (500rpm) the maximum peaks are lower than in 900ppm and 800ppm. The same thing occurs in 700ppm in front of 600ppm and 500ppm and in 400ppm in front of 300ppm. This means that in 1000ppm and 700pp the frequency is closer to the specific frequency of the rotation of the unit.

The specific frequency of a body is the fundamental frequency, the f_0, and how closer is a frequency to it, less interference (vibrations in our case).

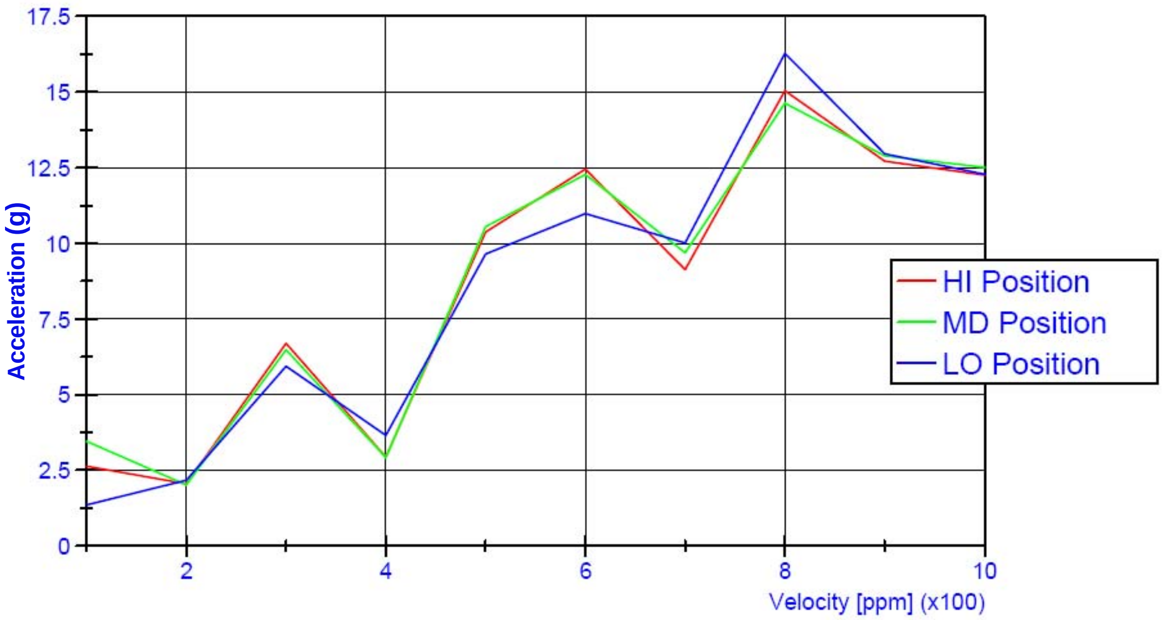


Figure 4.5.2.1 Maximum peaks of acceleration for X axis for each velocity

As we can see in the figures 4.5.2.2 and 4.5.2.3 the trend for the Y and Z axis is the same.

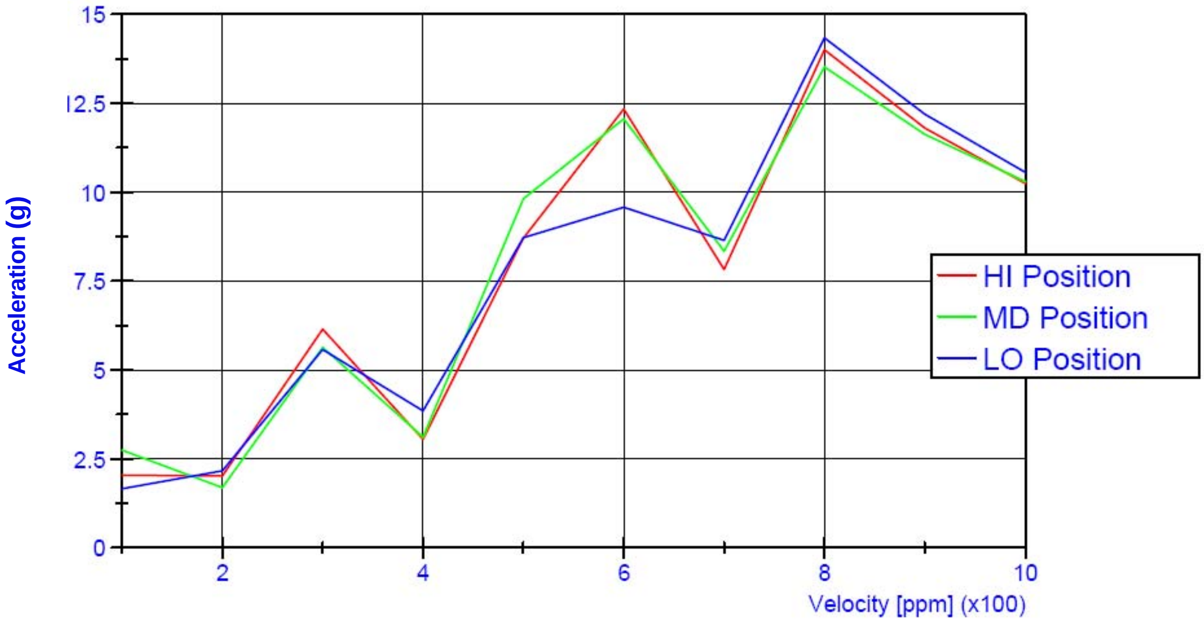


Figure 4.5.2.2 Maximum peaks of acceleration for Y axis for each velocity

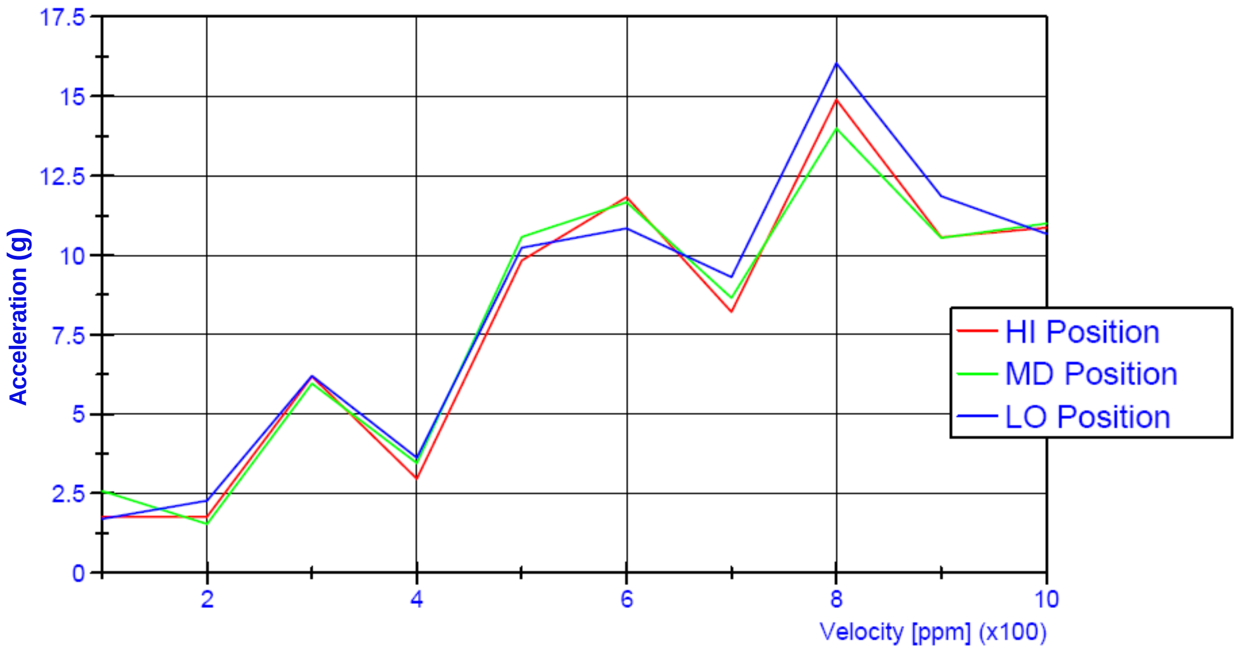


Figure 4.5.2.3 Maximum peaks of acceleration for Z axis for each velocity

4.5.3. FFT analysis

The frequency analysis, or First Fourier Transform, is the most interesting one because it will show us which frequencies are the most relevant and we will be able to identify these frequencies and relate them with the rotation of our table masses or knives.

With that information we will be able to choose the best counter-weight position to start in optimal conditions our dry-run analysis to check if all it's ok running at 1000ppm.

We expect that the most influent frequencies that we have to see in this FFT analysis are the frequencies corresponded to the rotation of the plate, to the rotation of two masses (the two knives), and to the rotation of all four masses presents in our plate.

We have calculated these frequencies:

$$1000ppm = 500rpm \rightarrow 500rpm \cdot \left(\frac{1min}{60\text{sec}}\right) \cdot 1\ rotation\ of\ the\ plate\ each\ revolution = 8{,}33\ Hz$$

$$500rpm \cdot \left(\frac{1min}{60sec}\right) \cdot 2\ rotation\ of\ knives\ each\ revolution = 16{,}66\ Hz$$

$$500rpm \cdot \left(\frac{1min}{60\text{sec}}\right) \cdot 4\ rotations\ of\ all\ mass\ in\ each\ revolution = 33{,}33\ Hz$$

To simplify, the frequency associated to the rotation of the plate will be called from now 8Hz, the one associated to the rotation of the knives for each unit revolution 16Hz, and the one associated to the rotation of all the four masses presents in each revolution of the unit 32Hz.

We have calculated the FFT for a frequency range of 500Hz, but really we only need a range of 32Hz to analyze these effects, because, as we can see in the figure 4.5.3.1, how many higher is the frequency, lower is the displacement produced by the acceleration or vibration corresponding to that frequency.

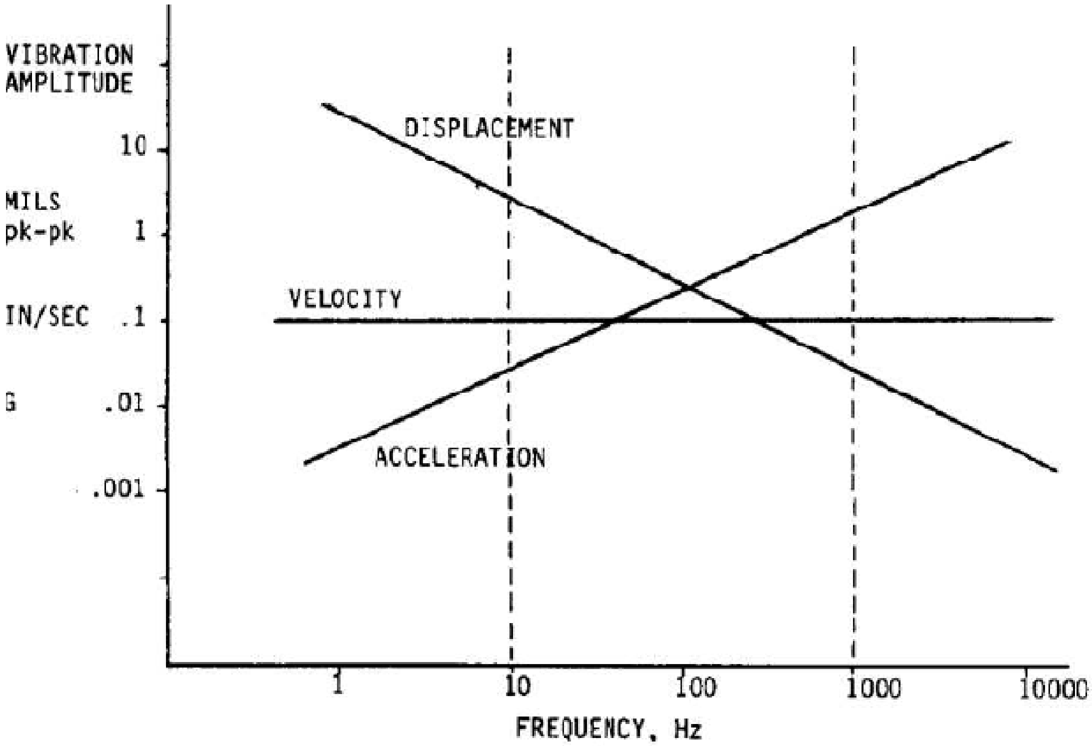


Figure 4.5.3.1 Relation between displacement/velocity/acceleration with the frequency

We are interested in the displacement done by the vibration of the unit; for that reason we are only interested in low frequencies.

Our study frequency range will be from 0 to 50 Hz.

4.5.3.1. FFT analysis with knives

We have to check if the expected frequencies are relevant in our FFT analysis of the unit running at 1000ppm, 500rpm.

As we can see in the figure 4.5.3.1.1, with knives the most relevant frequency and its surroundings, with so much difference from the others, is the corresponding to the knives revolution, cut revolution, at 16Hz.

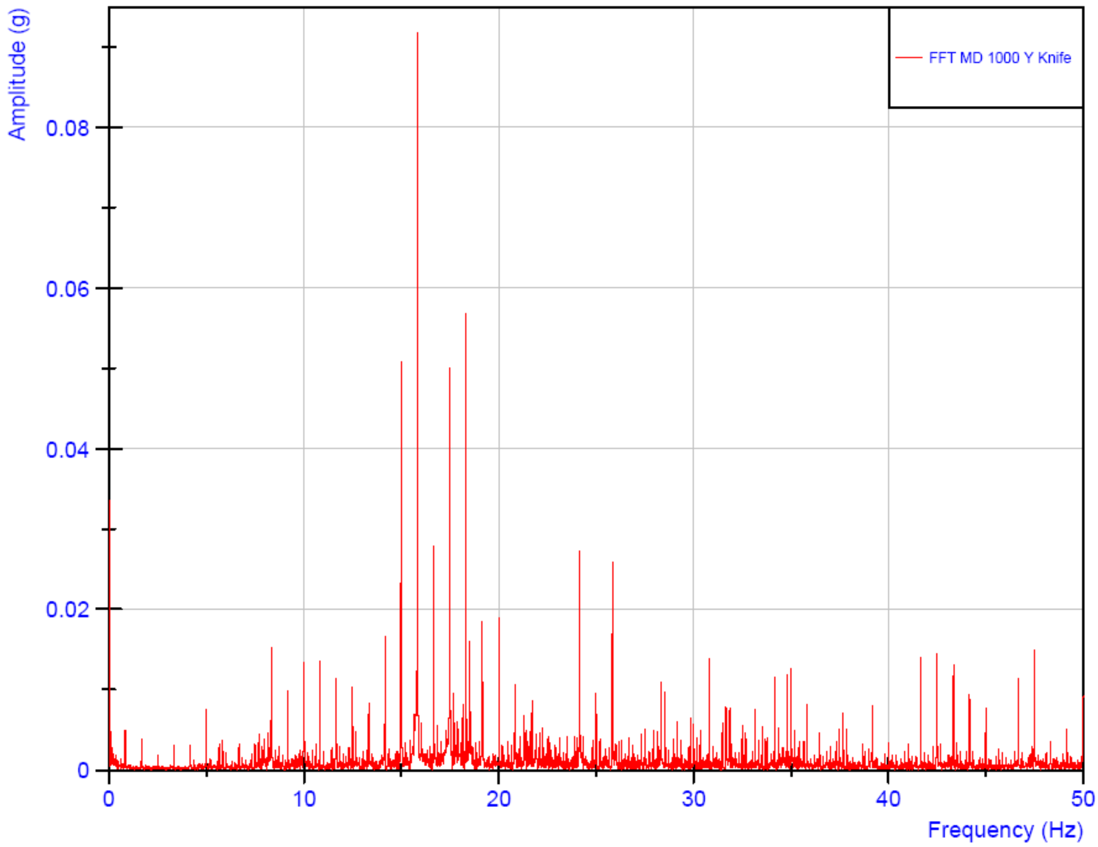


Figure 4.5.3.1.1 FFT analysis for 1000ppm in Y axis in Medium position

This has made us to take the decision of unmount the knives from the knives rotating supports in order to avoid the effect of the cut in each rotation and to have more information to decide about which position is the best one.

4.5.3.2. FFT analysis without knives

When we have unmounted the knives we started another acquisition campaign in order to see the influence of the three relevant frequencies in each revolution of the unit. We can see in the figure 4.5.3.2.1 the relevance of the frequencies in the Y axis. In the other axis exists the same behavior.

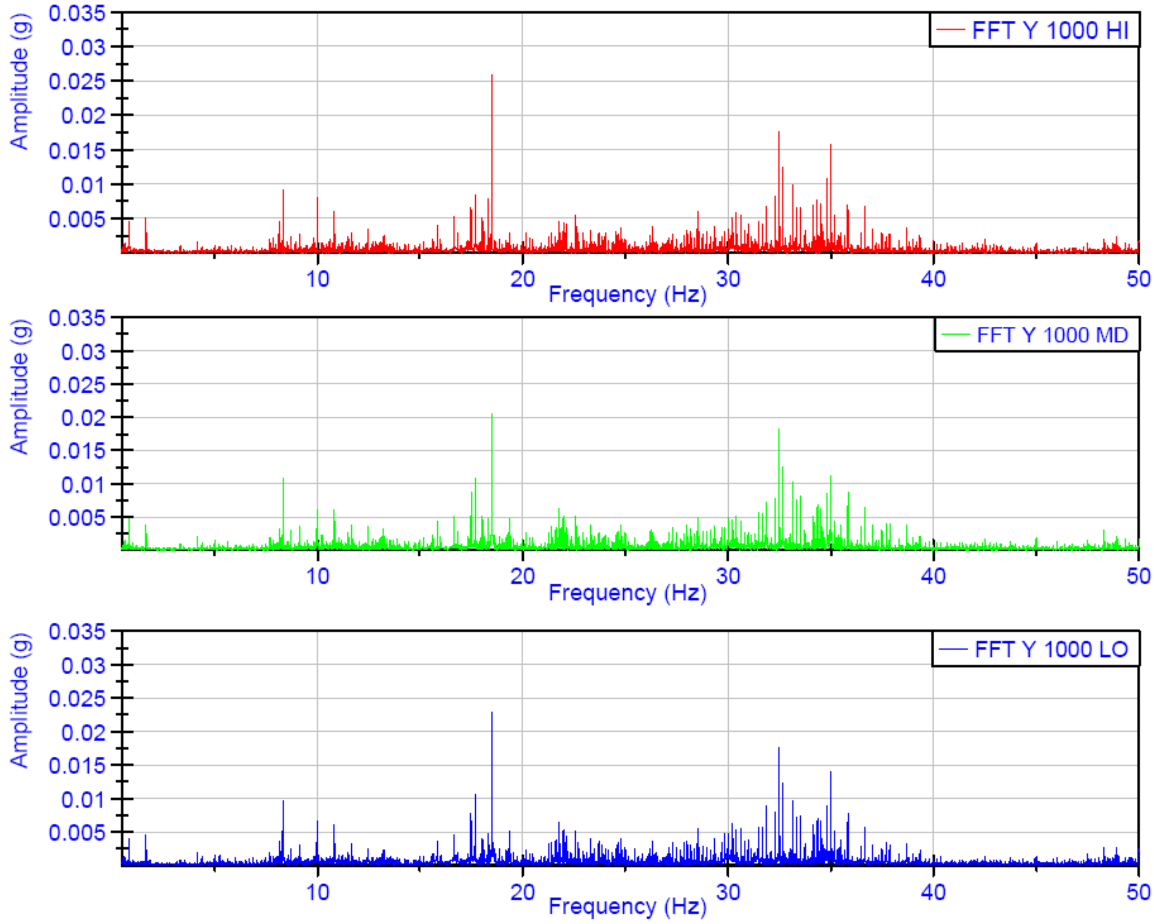


Figure 4.5.3.2.1 FFT analysis at 1000ppm for Y axis without knives for high, medium and low positions

The influence of the frequency associated to the revolution of the unit can be despised in front of the influence of the other two.

It seems that the relevance of the rotation of the knives supports is higher than the rotation of all the four mass.

It also seems that the better position could be the medium position. To compare it more closely we made the FFT analysis comparing medium position with 10 and 20 positions, as is shown in the figure 4.5.3.2.2, because they are only separated by 5mm one of each other.

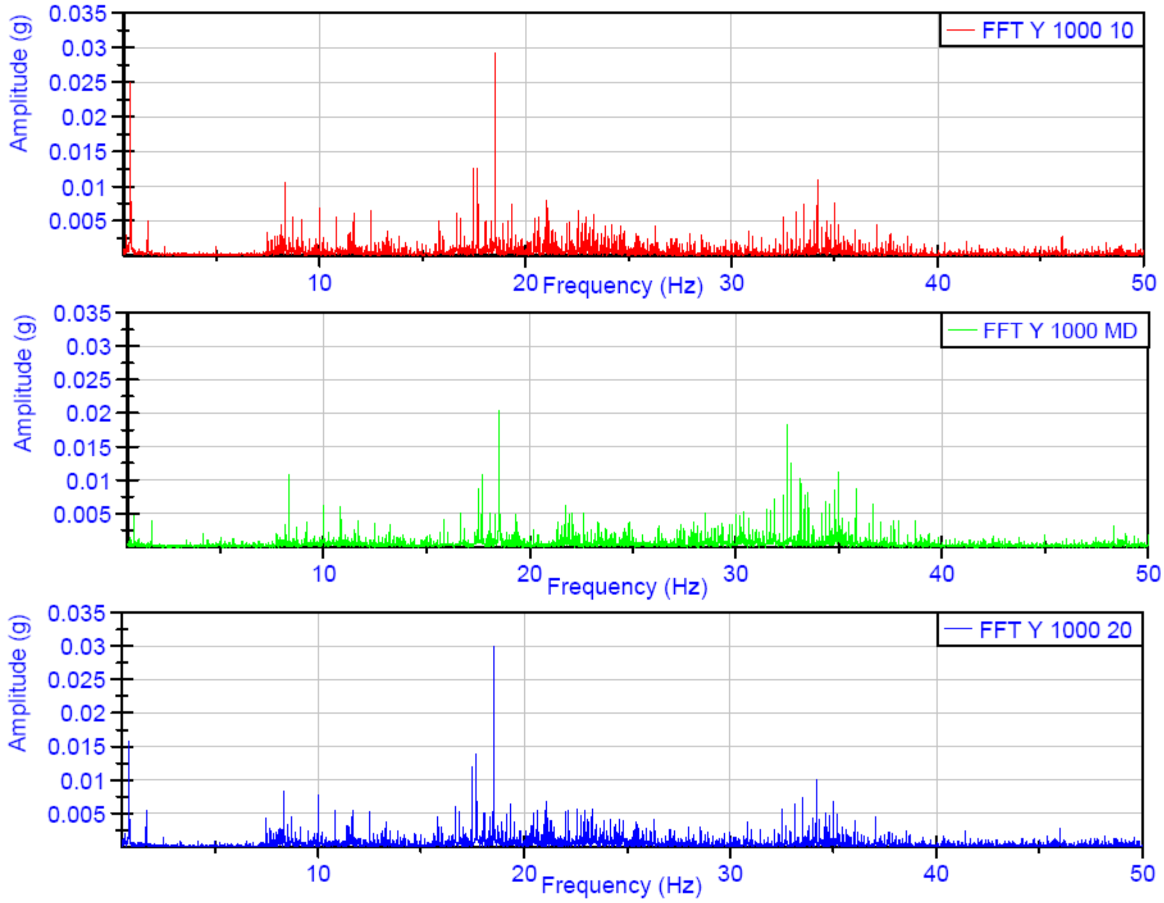


Figure 4.5.3.2.1 FFT analysis at 1000ppm for Y axis without knives for 10, medium and 20 positions

As we saw before, the 16Hz frequency is the most influent, we will have to decide the best position for the counter-weight analyzing this frequency first.

4.6. Best position. Result

To check and decide which is the best position where we have to place the counter-weight we have token the amplitude values of the two relevant frequencies of each position at 1000ppm (16Hz and 32Hz) and we have made a graphic, as we can see in the figure 4.6.1, to choose the better position for the most relevant frequency without knives.

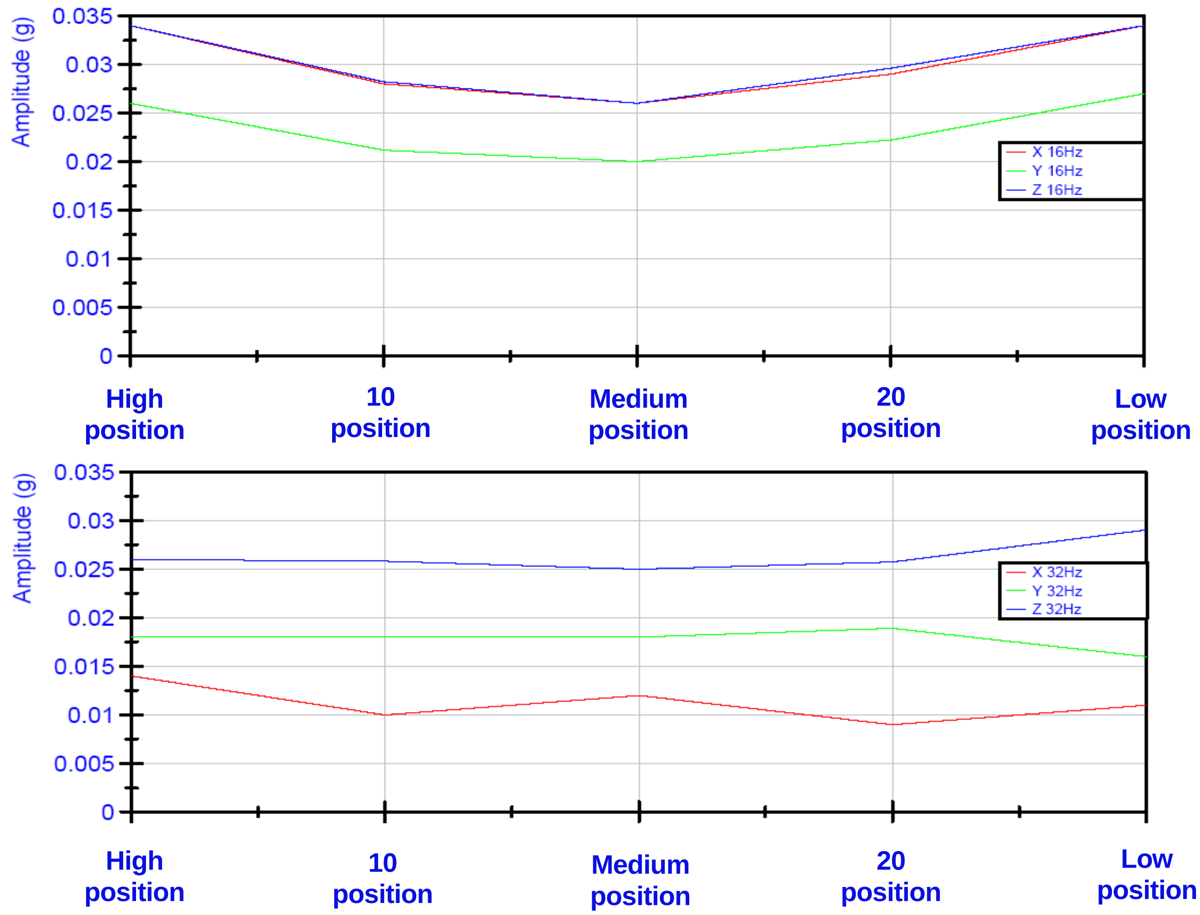


Figure 4.6.1 Amplitude values for 16Hz and 32Hz for each position and each axis

As we can see, the amplitude of the values for 16Hz are higher, then more important, than the 32Hz values, and for the 16Hz values the better position for each axis is the Medium position.

We have concluded that the better position to place the counter-weight in order to have a lower influence of the amplitude of the vibration produced for the rotation of the knives, without considering the cuts, only the mass, is the Medium position.

From now all the next analyses, dry run analysis and raw material analysis will be done with the counter-weight in medium position.

5. Temperature analysis

5.1. Introduction

The purpose of doing a temperature analysis is to check if all the critical components have a good stationary behavior during the machine's working.

These critical points are the bearings, the components more affected by the temperature increasing in the rotation speed up of the machine.

We want to have the trend of the maximum temperature of these points in order to know if we have to change these components. The maximum temperature allowed by the bearings in order to have a good behavior is 60°C-65°C.

5.2. Thermocamera

The instrument that we have used to acquire the temperature data is a thermocamera. We have used a ThermaCAM™ P640 from FLIR Systems.

To acquire data with the thermocamera you have to place it in front of where you want to control the temperature and check if all the area that you want to control is inside the display limits of the instrument.

Then you have to select the points that you consider critical, in order to show you all the time the temperature of these points. You can see in real time the variations of temperature.

It also have the feature to make photos every period of time that you want in order to be able to work with that photos with a post-analysis software.

5.3. Acquisition campaign

We want to have the temperature trend in the stationary state of the unit's working, for that reason we have make this acquisition campaign in the dry run analysis of 6 hours that we have performed.

To acquire the temperature data we placed the thermocamera one meter away from one side of the machine from where it can record the thermical behavior during the time of the bearings as is shown in the figure 5.3.1.

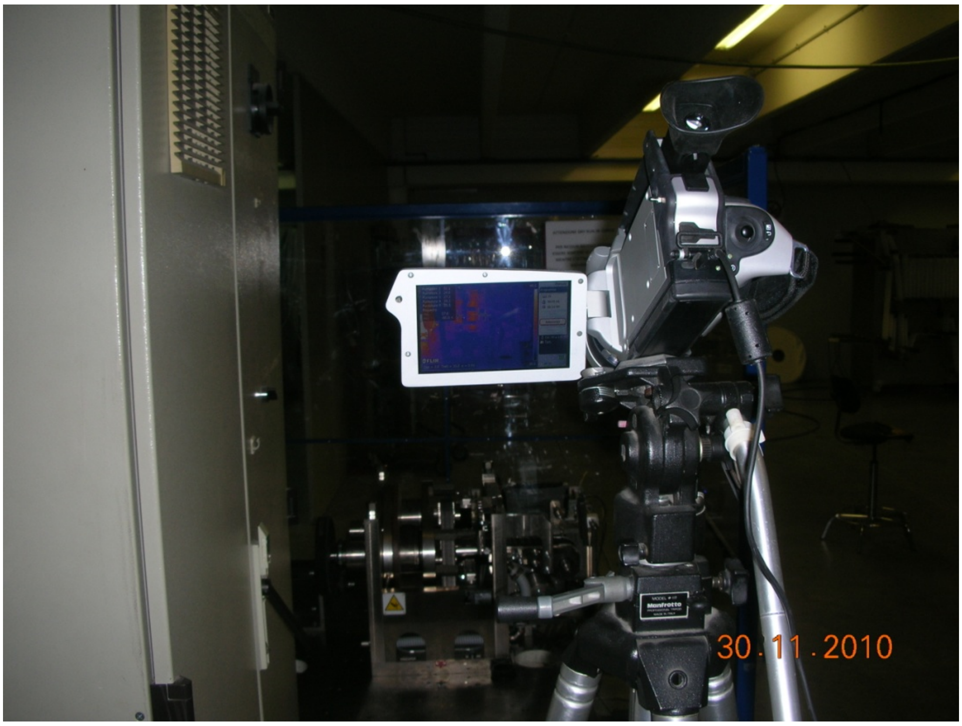


Figure 5.3.1 Thermocamera placed in front one side of the machine

As is shown in the figure 5.3.1 we don't have any protection in front of the thermocamera, because if we put a panel in front of it, it cannot measure the temperature correctly.

For that reason we have programmed the thermocamera to make a temperature photo every 15 minutes in order to have the maximum value of the hottest critical point and a temperature map of all the structure without putting in risk our integrity, because we can watch all the photos after we have finished the dry run 6 hours analysis with the unit stopped.

5.4. Analyzing data. Temperature trend results

As we expected, the temperature behavior started growing up quickly but with the time it has been stabilized around a value. We have performed the trend graphic shown in the figure 5.4.1. The table with all the values is in the Annex A.

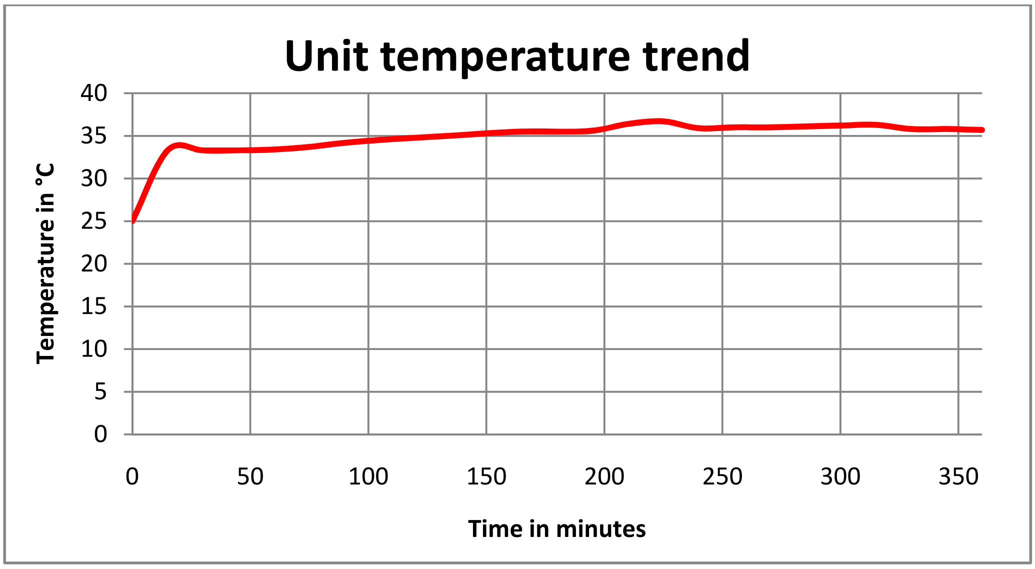


Figure 5.4.1 Unit maximum temperature trend of the critical components

We can see that the temperature is stabilized at 35,7°C of maximum value, very lower than the maximum value allowed by the used bearings, 60°C-65°C.

We also worked with the thermocamera photos with the post analysis software of FLIR Systems, ThermaCAM™ QuickReport, to see the instant values of each critical point, bearings, shown in figure 5.4.2. We can also see the maximum stationary temperature of 35,7°C that concludes that our unit has no temperature problems induced by the speed up. Temperature OK.

Figure 5.4.2 Temperature map with higher temperature and instant values of critical points

6. Noise analysis

6.1. Introduction

The objective of doing a noise analysis is to check that our unit doesn't pass the maximum allowed of decibels when it is working at the new velocity.

We have to consider that we are making this analysis without noise enclosure in the lab, which means that we have more or less 10-15 decibels more than the same unit's working in its correct emplacement in the production line with its noise enclosure.

The maximum allowed by the Art. 189 of the Law statement of Italy is 87 decibels, but considering that the unit is naked, we can arrive at 98-100 decibels in our study situation.

6.2. Sound level meter

The instrument used to measure the noise produced by the machine's working is a sound level meter, in concrete the SLM-1352A from ISO-TECH, with a range of 30 to 130 decibels, that is correct for our purpose because we have a limit of 100 dB as maximum.

The working of a sound lever meter is easy, it's a microphone that acquires the ambient noise produced at 1 meter away from it and shows the instant value in its display.

This one, as so many other sound level meters in the market, has two interesting functions, one that allow us to place a maximum value, for example in our case 100dB, and the sound level meter advertise us every time that we reach this level with a visual and/or sound advertisement.

The other interesting function is the Maximum value button, a function that only shows the maximum value measured by the sound level meter since you press it till you want. Is an interesting feature in applications where is only needed the maximum value in a concrete period of time, like our case.

It can also be linked to a PC in order to make an exact number of continuous acquirements in the time, but for our study we don't need to do this, reading the value in the display is enough to check that we are not reaching our limit.

6.3. Acquisition campaign

We have measured the noise data with the sound level meter during the dry run analysis with the objective of having a graphic with the noise trend of the unit in its initial phase till its stationary behavior.

This dry run analysis is 6 hours long, enough time to check if the unit noise trend is stable around a value lower than the maximum allowed.

To acquire the noise value we placed the sound level meter one meter away from the unit, as we can see in the figure 6.3.1, and we pressed its maximum value button in order to see the highest value acquired by it. We repeat this every 15 minutes to have enough points to perform a trend graphic.

Figure 6.3.1 The sound level meter measuring unit's noise during the dry run analysis.

6.4. Analyzing data. Noise trend results

When we had all the values of the maximum noise for each period of 15 minutes we performed the noise trend graphic, figure 6.4.1, showed below. The table with all the values is in the Annex A.

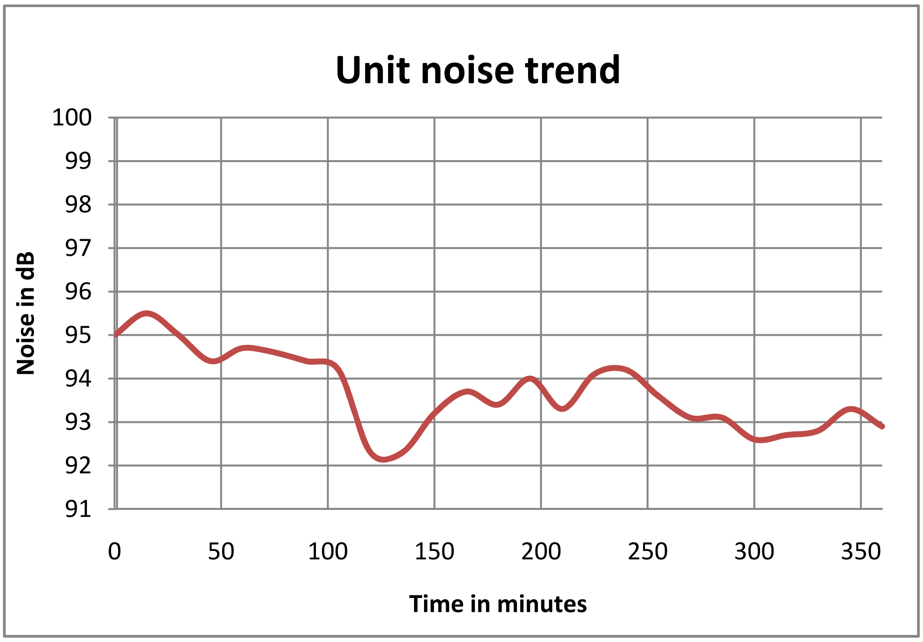


Figure 6.4.1 Unit noise trend during the 6 hours of the dry run analysis

As we can see, after six hours of working the unit has a maximum value of noise stable around the value of 93 decibels.

As we said, the maximum allowed value is 90 decibels in normal working conditions, but we are in the lab testing the unit without noise enclosure, that can decrease the noise in 8-10 decibels.

Considering that fact, we are in 83-85 decibels at working conditions, lower than the maximum allowed value of 90 dB. The noise test points that the working at 1000ppm is OK in sound level terms.

7. Torque analysis

7.1. Introduction

We have done this analysis to check that the nominal torque solicitation of the motor by the unit when it's working at the new velocity of 1000ppm (500rpm) has a constant behavior when it reaches the stationary state.

7.2. Acquisition campaign

To reach the stationary state we have to analyze it in the dry run analysis of 6 hours that we have done in the lab.

To acquire the data we don't need any external device as happened with the temperature and noise analyses, because we can check and acquire manually the nominal torque solicitation directly from the controller PC that manages the velocity and the parameters of the unit motor.

We are not going to analyze the value of this torque because in the real application, out of the dry run analysis of 6 hours, we are going to change the actual motor for a higher one as we said in the Rotational inertia check chapter, we only want the percentual value of the nominal torque of the motor in order to see if it is always around a value, with a constant behavior.

7.3. Analyzing data. Torque trend results

With all the percentual values of the nominal torque of the motor acquired every 15 minutes, that are all gathered in a table in the Annex A, we have done the graphic of the torque trend which is shown in the figure 7.3.1

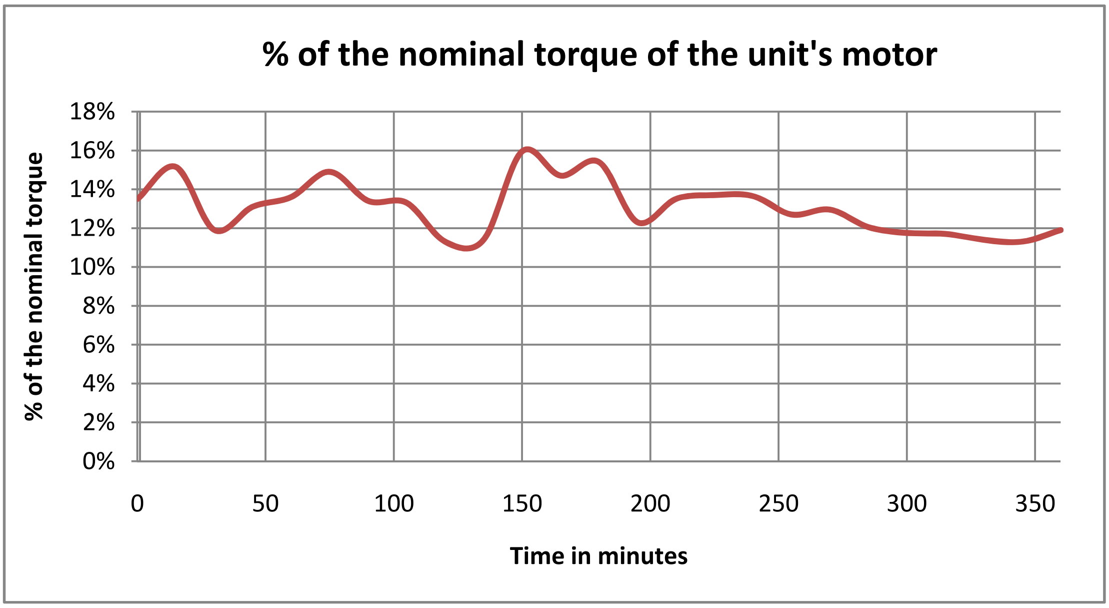


Figure 7.3.1 Trend of the nominal torque solicitation of the unit's motor

As we can see, in the time the value is practically the same, around 12% of solicitation, a good value, and during all the analysis the maximum and the minimum values are not more different than a 5% of the nominal torque.

We can assume that the torque is more or less constant in all the process, that's correct and shows that there isn't any problem that requires more power of the motor with the time.

8. Raw material analysis

8.1. Introduction

To check the behavior of the unit in a real application we have to mount it into a bench test in the R&D Laboratory to test it with the vacuum system on, with the raw material and with the disposable tape, like in its real working.

We have started this analysis at 100rpm and increased till arrive at 500rpm (1000ppm) in order to see the cut and application finish at each speed and to do a quality control to check if it's all ok or we need to modify something in our unit.

In our bench test we can control the value of the vacuum, the speed of all the axis motors, the un-winders and the conveyor. The vacuum value is configured at a pressure of 122 milibars and the conveyor at a pressure of 78 milibars.

The raw material is the non-woven material that covers the diaper and where the disposable tape will be attached. It's from the manufacturer Fiberweb and its code is 022HI00170. It has a width of 170mm and a length of 4900m.

The disposable tape is from the manufacturer 3M Scotch™ and its code is CZL 3910/L. It has a width of 62mm.

8.2. Bench test and unit assembly

To insert the unit in the bench test we have studied the way to do it before with the help of a 3D CAD program (Solid Edge).

We had the bench test created in Solid Edge format and we have moved and positioned there our unit. With the 3D CAD program we have designed all the modifications of the supports and plates and created specific pieces that we need to move and fix our unit in the bench.

In the figure 8.2.1 we can see the raw material path. It starts in the un-winder of the right, follows guided by the idle rolls and the nip roll, then enters into the alignment system in order to check the position of the non-woven before it enters into the unit, then it is guided by the conveyor to the cutting zone, and then it exits to the re-winder of the left guided by more idle rolls.

At the end, in the real montage we had another unit in the bench test mounted before, and for that reason our unit was moved two back plates to the right and changed the position of the alignment system just after the nip roll, but the work is the same and the modifications are still valid.

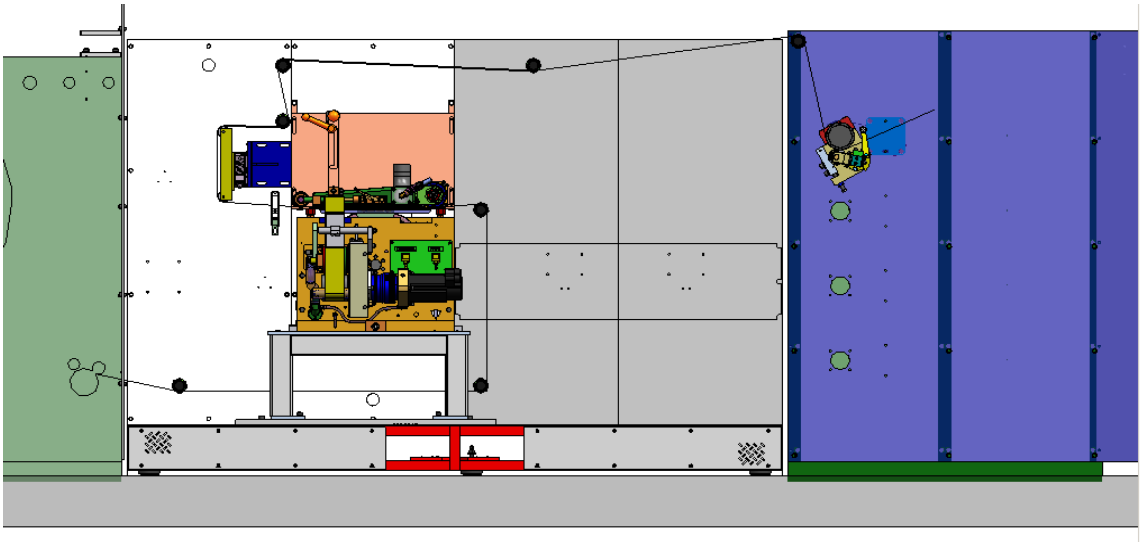


Figure 8.2.1 Raw material path

The disposable tape un-winder is placed in front of the bench test and the path that it follows is shown in the figure 8.2.2, over the security doors.

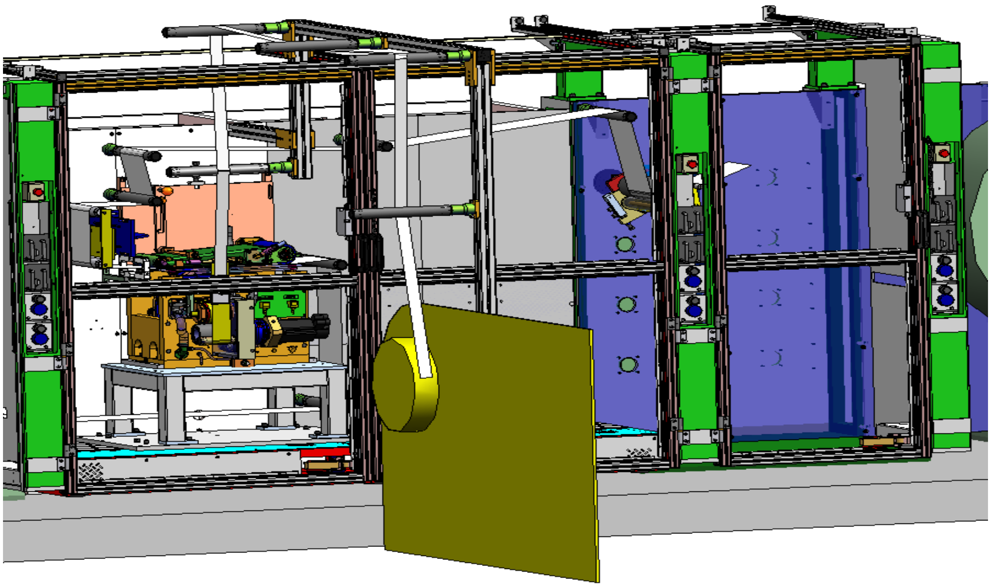


Figure 8.2.1 Unit and disposable tape un-winder

8.3. Bench test working. First results

Once we have all mounted in our bench test, as shown in figure 8.3.1, we have started running this analysis.

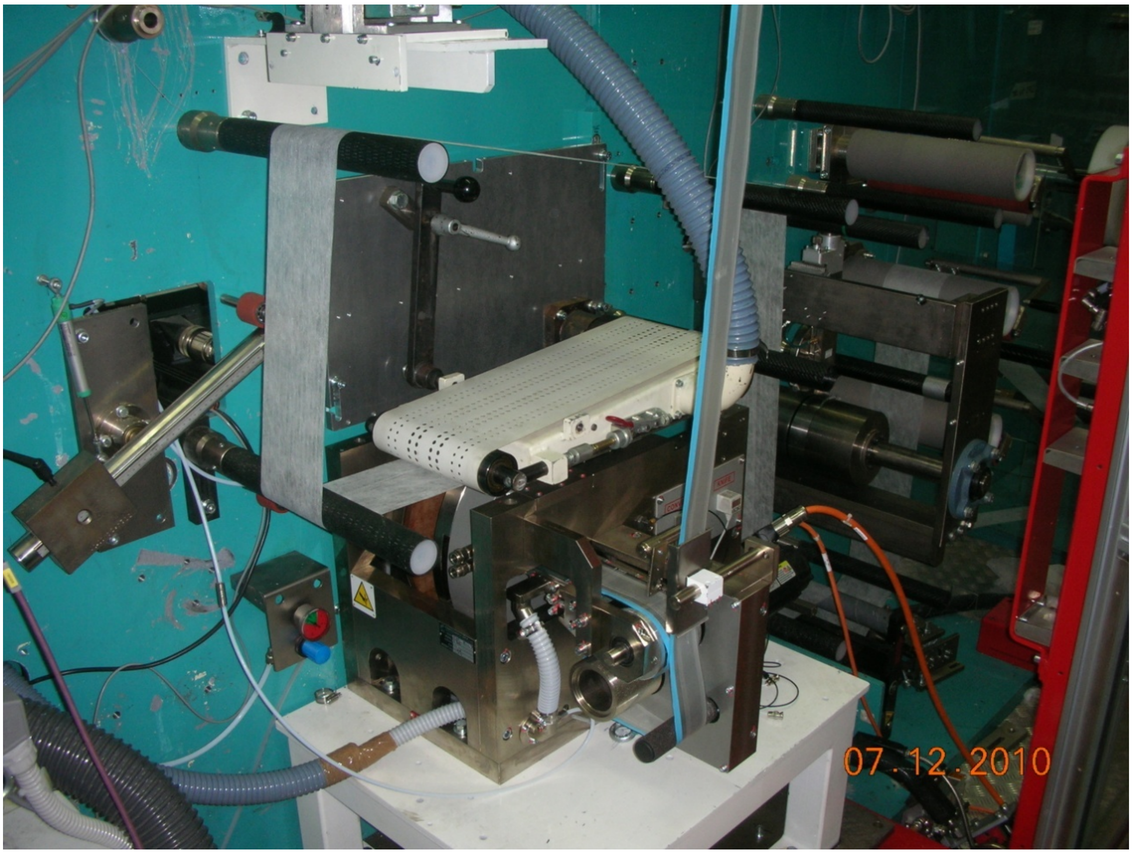


Figure 8.3.1 Our unit mounted in the bench test with all ready to start running

The first results at a very lower speed (about 30ppm) were good, but when we increased our velocity to 200ppm our cutting and application results weren't good.

The first problem that we had it's in the fixed knife produced by the interference between it and the rotating knives during the dry-run 6 hours test.

The interference was too much strong and it damaged the cutting zone of the fixed knife as we can see in the figure 8.3.2, a photography taken from the microscope showing these defects.

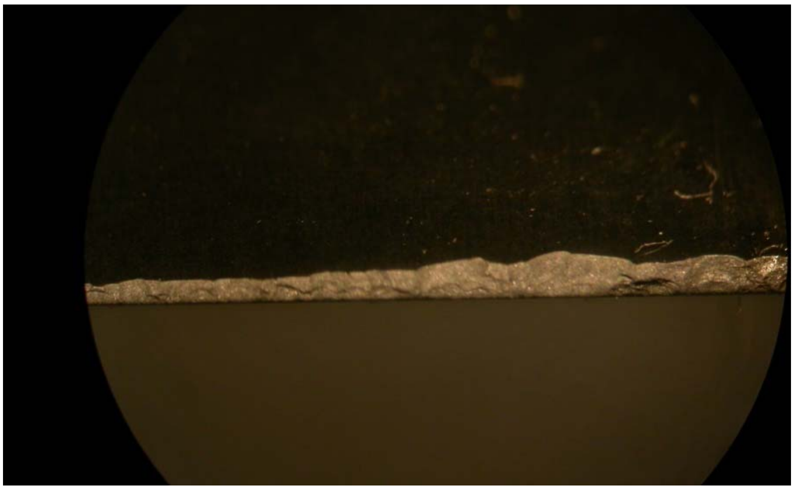


Figure 8.3.2 Defects in the cutting zone of the fixed knife.

The second problem that we noticed is the temperature of the fixed knife. We need to turn on the refrigerant at lower speeds also. We take a chiller with glycol from production area of the company to down the temperature reaching -6°C.

Once these problems were solved, we started to run again. The results were good till we arrived at 375rpm (750ppm), after this speed appeared problems in the cutting of the disposable tape.

It seemed that the problem is focused in the temperature, to avoid glue residues in the knife, because it works correctly for 15-20 applications of disposable tape, but then appeared for two or three times applications of 4 pieces together and then started to apply correctly for 15-20 more disposable tapes. This is shown in the figure 8.3.3 below.

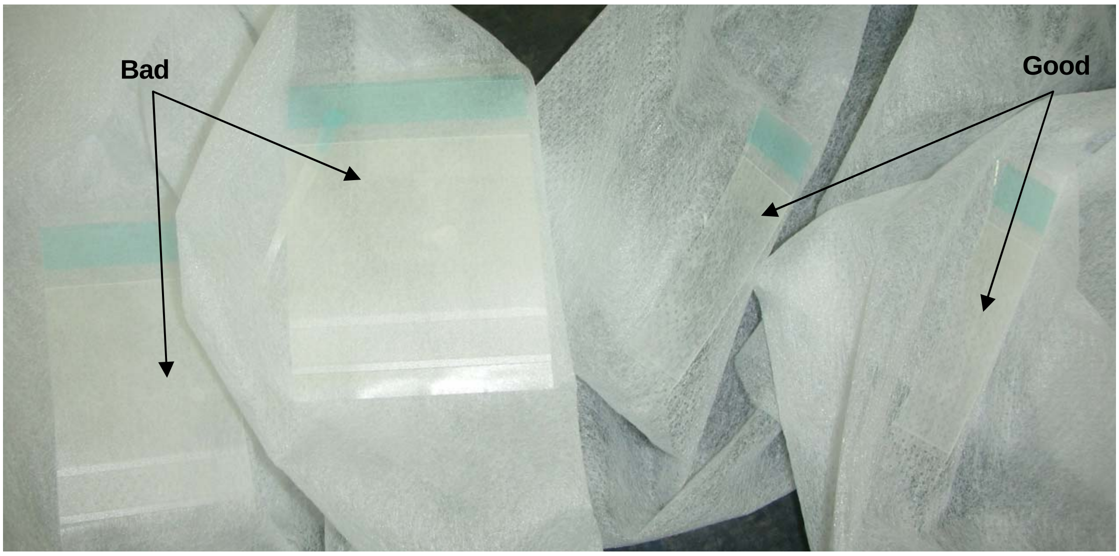


Figure 8.3.3 Defects of the cutting at 750ppm

In order to fix these problems and reach our goal speed, we have made two modifications at our pieces and changed our chiller to a higher one.

We have designed our improvement kit.

8.4. Improvement kit

The temperature is a problem, and we have two ways to down it from -6°C to at least -12°C.

The first way that we followed was to use a higher chiller, shown in the figure 8.4.1, with more power to refrigerate. It was a simple upgrade.

Figure 8.4.1 The higher chiller

The other way was to modify the support of the fixed knife.

As we said in the chapter 3, the fixed knife cannot be refrigerated directly for its material properties. For that reason we refrigerate its steel support and it refrigerate the fixed knife by heat transmission.

We have made the inside conducts greater. Before were of 4mm of diameter, and now are 6mm. The input of the glycol is the double of large now also.

With these two modifications now we can reach -6°C at the support and -3,5°C at the counter knife. (This gradient of temperature is produced by the thermical energy produced by the kinetic energy of the knives cut)

The other problem it's the interference between the rotating knives and the fixed one. During the dry run test of 6 hours this interference produced relevant damage to the fixed knife, and it can happen again if we don't regulate accurately the position of the rotating knives.

To solve this problem and have a longer life for it, we have designed a modification of our fixed knife, giving to it much more surface of contact for the rotating knives, shown in the figure 8.4.2, before arriving to the cutting area of the counter knife. This contact area has an inclination of 1° respect of the frontal surface of the knife to regulate the interference and do the cut accurately with less damage to the cutting zone.

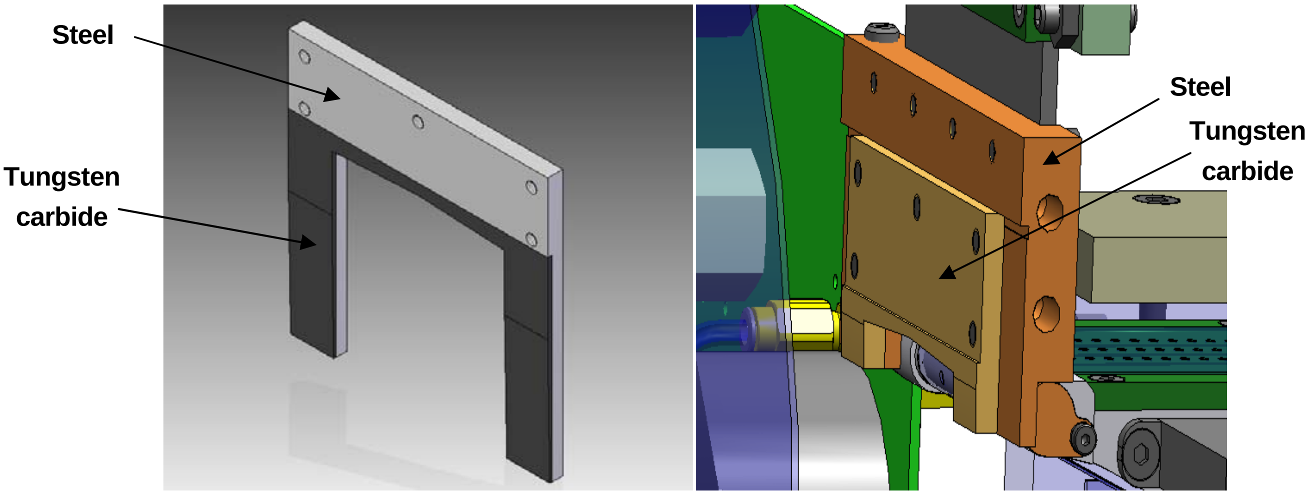


Figure 8.4.2 Fixed knife modified (left) and old fixed knife (right)

This will give a longer life to our fixed knife.

With those modifies we have run again the unit and we have saw the new results and made two more analysis to check that the results are ok.

8.5. Bench test working. Final results and analyses

With the new modifies the product results at 1000ppm are ok in a short time test, but we wanted to see also the cut real behavior and the temperature in the cutting zone.

For this we used a high speed camera to record and view the cuts in slow motion and a thermocamera to check that the temperature is still correct.

8.5.1. High speed camera analysis

To do this analysis we used a high speed camera from MegaSpeed configured to record 650 frames per second to see the cut in slow motion frame to frame to check if the cut, the vacuum and the flexion of the counter knife are all ok.

We placed the camera in front of the side of the unit and we have illuminated it with the help of a focus, as is shown in the figure 8.5.1.1.

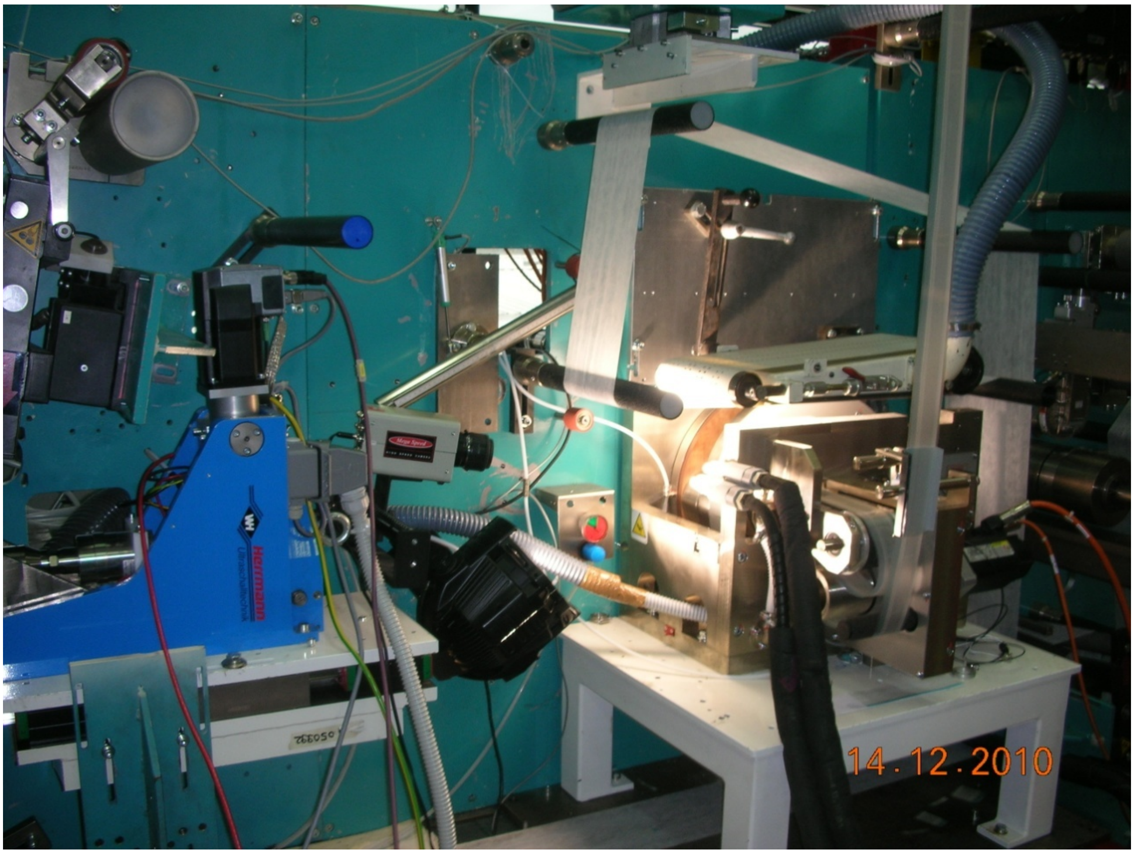


Figure 8.5.1.1 High speed camera analysis in the bench test

In the figure 8.5.1.2 we can see the frames were the cut is correctly produced.

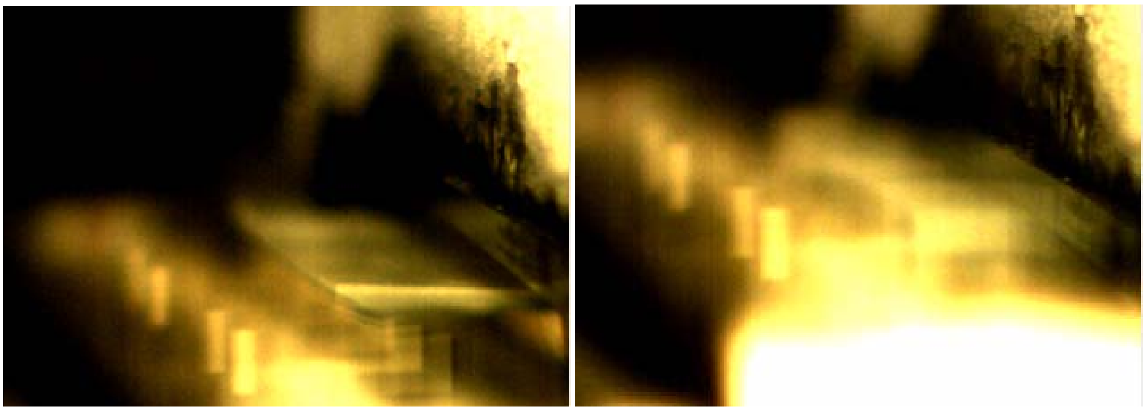


Figure 8.5.1.2 Frames of a cut between knives

As we see in these images and in the finished material, the cut and application are ok. Now we don't have cutting or application defects.

8.5.2. Thermocamera analysis

The way to do this analysis is the same that we did before in the dry-run long time chapter.

Now we placed the thermocamera behind our bench test, shown in the figure 8.5.2.1 recording the area that interests us, the cutting zone, in order to check that the temperature is correct.

Figure 8.5.2.1 Thermocamera placed behind the bench test to record the cutting zone temperature

As we can see in the figure 8.5.2.2, the instant measure of the temperature shown in a thermocamera photo is of -3,6°C, a good value to avoid glue problems in the counter knife.

We are ok with the temperature also.

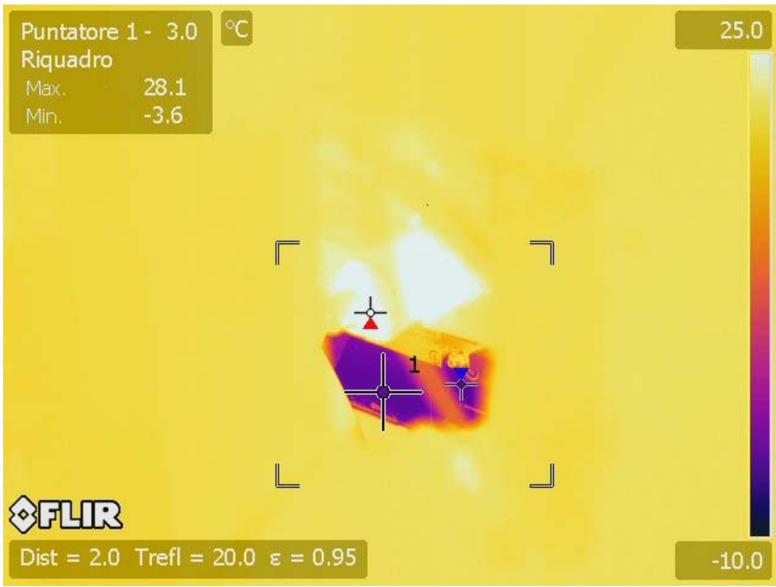


Figure 8.5.2.2 Thermocamera photo

9. Quality control

9.1. Introduction

To define the quality of the results obtained during the raw material test at our goal speed we have done a manual quality control test in order to finish all our study if the results are ok.

We have done this control in a range of 100 pieces of disposable tape at the velocity of 1000ppm.

We have controlled that all 100 pieces are applied in the non-woven material and if they are well placed along the material (peach between tapes) and if they have the correct width.

As we said before, we have done all this measures manually, as is shown in the figure 9.1.1, with a rule with ±1mm of tolerance.

Figure 9.1.1 Manual measurements of quality control with our measurement instrument.

9.2. Results

For the attribute analysis:

In the range of 100 pieces that we have analyzed, all are applied, not miss anyone.

This result is OK, we have no problems of applying.

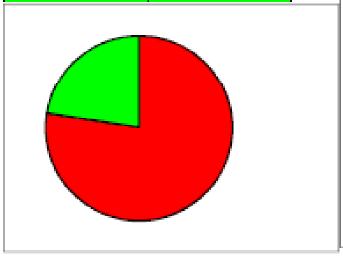
For the variable analysis:

The desired path value is 470mm, and as we can see in the figure 9.2.1, a Gaussian analysis with a tolerance of ±3mm, our media is in 466,41mm and we are in the left of our desired Gaussian bell.

SPECIFICHE	
LSL=	467,00
Target=	470,00
USL=	473,00

PROCESSO	
media=	466,41
dev_std=	0,78

INDICATORI STATISTICI		
Tgz=	-4,58	NO
Cr=	0,78	
Cpk=	-0,25	NO
L_OOL=	774.140,12	
U_OOL=	0,00	
OOL=	774.140,12	



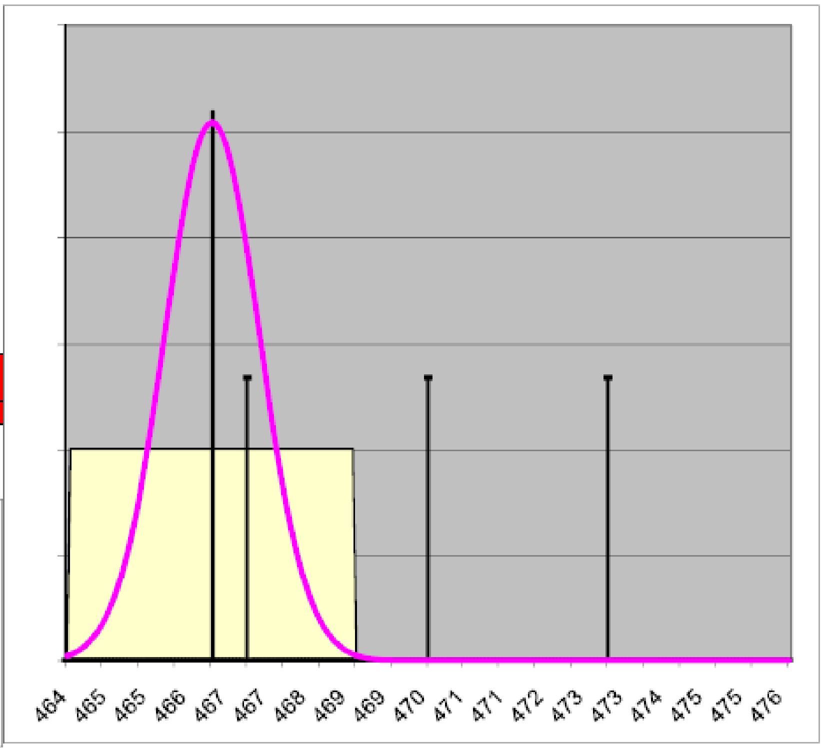


Figure 9.2.1 Gaussian analysis of the path of our disposable tapes

As we can see also in the figure 9.2.1, our statistical indicators show that it isn’t capable. We have to configure our path in our machine to 473mm in order to be inside our tolerance limits and with a media of path value of 470mm and move our Gaussian bell into the right.

The desired width of the disposable tape is 12mm, and as we can see in the figure 9.2.2, our Gaussian analysis shows that we are in a media of 11,9mm of width.

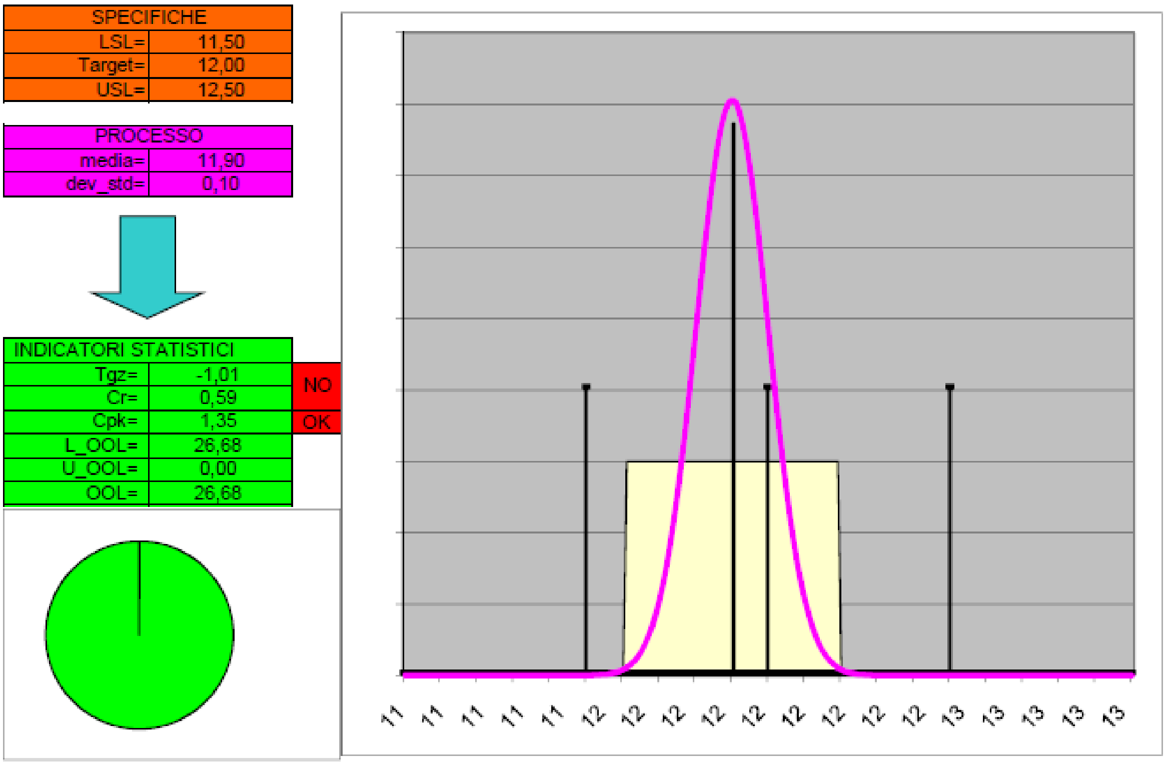


Figure 9.2.2 Gaussian analysis for the width of our disposable tape.

Statistical indicators show us that the process is capable, but if we configure the machine to have a width of 12,1mm, we will move our bell to the right and we will obtain a media of 12mm.

We can conclude that we have a good application quality in our product at 1000ppm, but it can be optimal with minimum changes in our machine.

We have achieved our objective.

Conclusions

I noticed doing this work the importance to know what, why and how we are going to do all the study before starting it to anticipate us to the possible problems that we can have. By the way, we are still having new problems that we have to solve.

A previous study of the relevant variables is very important to show us the behavior when we are running real application analyses.

The study of the application in a bench test is the closest situation to the real application of the unit, is the step where we have to pay more attention at its behavior.

At the end, in our case, we reached our objective of cut and apply 1000ppm in our diaper with some modifications at the starting situation.

Modifying the support and the counter knife piece as we said in the report will let us to work correctly at the scope velocity.

As a future improvement, it could be interesting to design a new refrigeration system to our fixed knife support in order to reach lower temperatures for future speeding ups in that kind of rotation cut units.

All the previous steps done, with their respective analyses, are important and necessary to keep working in the right way and arrive at our goal. All the work is important, theoric and practical work.

Thanks to

To Fameccanica.Data for giving me this opportunity to do my master thesis here, in special to Mr. Jordi Ballesté, Mr. Carlo Bianco and Mr. Giampiero De Angelis.

To Mr. Gianni Campatelli for being my tutor in the University of Florence and giving me his support and help in all related about my thesis and Erasmus period in Italy and sharing with me his knoweldege.

To my family and friends to give me their support.

To Mr. Fabio d'Aniello and Mr. Fabio Intelligente for their help with the acquisiton campaigns.

And my greater and special thanks to Mr. Sergio Lupinetti and Mr. Diego Gualtieri for their daily support and help for the work and the thesis, and for being also my friends out of the work time.

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Annex A

Bosch Rexroth motor technical datasheet

VP7 Accelerometer technical datasheet

Inertia Calculus

Dry-Run results

Fixed knife improvement design

Test bench layout

Electric Drives
and Controls

Hydraulics

Linear Motion and
Assembly Technologies

Pneumatics

Service

Rexroth
Bosch Group

Rexroth IndraDyn S
Synchronous Motors MSK

R911296289
Edition 04

Project Planning Manual

4.7 MSK071

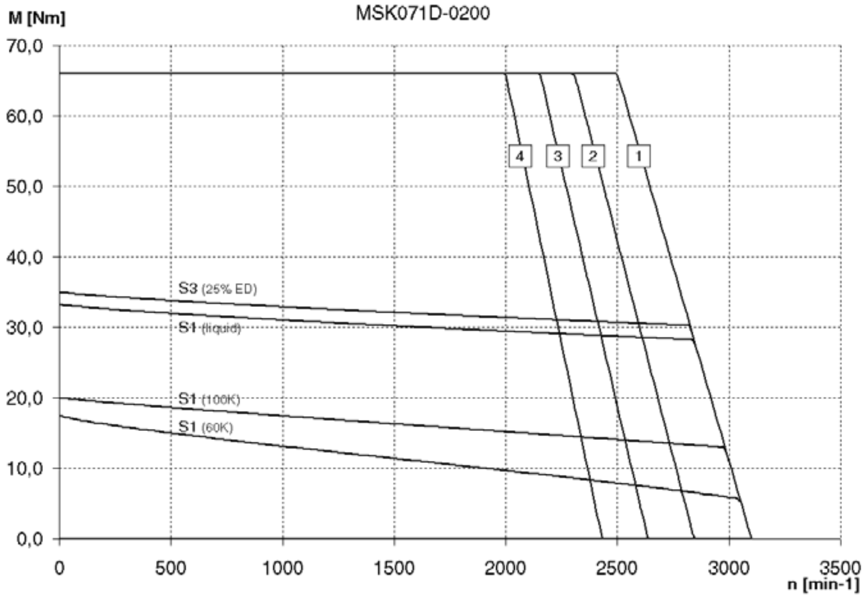
MSK071D Data Sheet

Description	Symbol	Unit	MSK071D-0200	MSK071D-0300	MSK071D-0450
Continuous torque at standstill, 60K	M_{0_60}	Nm	17.5	17.5	17.5
Continuous current at standstill, 60K	$I_{0\_60(eff)}$	A	7.3	9.0	15.4
Continuous torque at standstill, 100K	M_{0_100}	Nm	20.0	20.0	20.0
Continuous current at standstill, 100K	$I_{0\_100(eff)}$	A	8.6	10.7	17.6
Continuous torque at standstill, surface	M_{0_S}	Nm	i.p.	i.p.	i.p.
Continuous current at standstill, surface	$I_{0\_S(eff)}$	A	i.p.	i.p.	i.p.
Continuous torque at standstill, liquid	M_{0_L}	Nm	33.3	33.3	33.3
Continuous current at standstill, liquid	$I_{0\_L(eff)}$	A	13.9	17.2	30.3
Maximum torque	M_{max}	Nm	66.0	66.0	66.0
Maximum current	$I_{max(eff)}$	A	32.8	40.5	69.3
Torque constant at 20°C	K_{M_N}	Nm/A	2.63	2.12	1.25
Constant voltage at 20°C	K_{EMK_1000}	V/ rpm	162.0	134.0	77.1
Winding resistance at 20°C	R_{12}	Ohm	1.87	1.26	0.45
Winding inductivity	L_{12}	mH	13.1	10.7	3.2
Discharge capacitance	C_{ab}	nF	7.8	7.2	7.8
Number of pole pairs	P		4	4	4
Moment of inertia of rotor without brake	J_{rot}	kgm²	0.0025	0.0025	0.0025
Thermal time constant	T_{th}	min		54.5	30.5
Maximum speed	n_{max}	rpm	4,000	4,500	6,000
Mass	m	kg	18.0		
Sound pressure level	L_P	dB(A)	< 75		
Ambient temperature during operation	T_{um}	°C	0 to 40		
Setup elevation	h	m	1,000 above MSL		
Degree of protection			IP65		
Insulation class			F (according to EN 60034-1)		

Fig. 4-40: MSK071D Data sheet

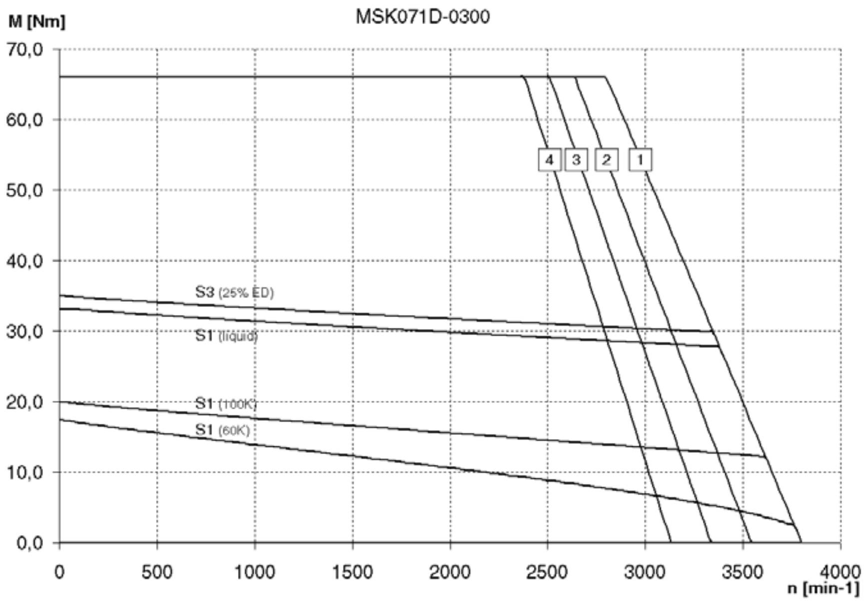
Rexroth Bosch Group

MSK071D characteristic curves



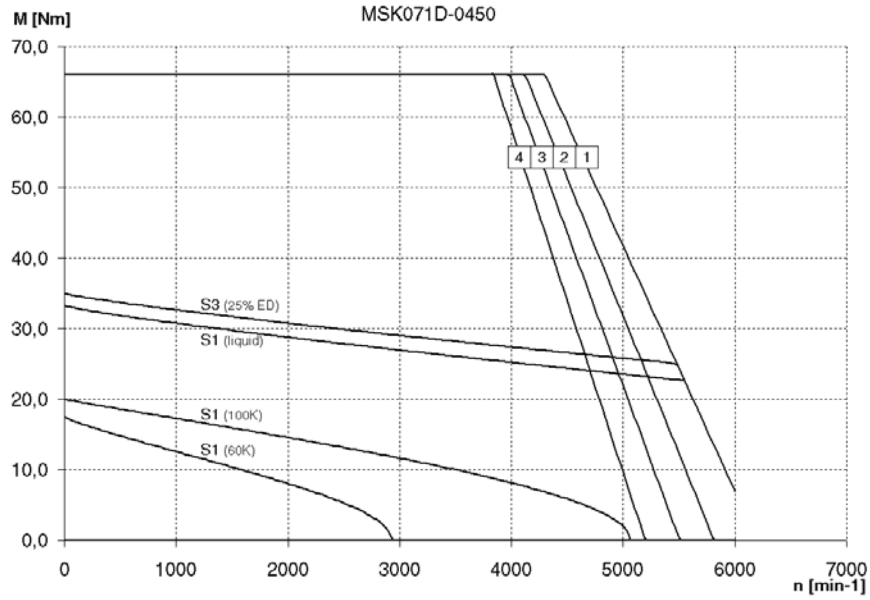
[1]: M_{max} for IndraDrive, controlled feed, 3 x AC 400V
[2]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 480V
[3]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 440V
[4]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 400V

Fig. 4-41: Speed-torque characteristic curve of MSK071D-0200



[1]: M_{max} for IndraDrive, controlled feed, 3 x AC 400V
[2]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 480V
[3]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 440V
[4]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 400V

Fig. 4-42: Speed-torque characteristic curve of MSK071D-0300



[1]: M_{max} for IndraDrive, controlled feed, 3 x AC 400V
[2]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 480V
[3]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 440V
[4]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 400V

Fig. 4-43: Speed-torque characteristic curve of MSK071D-0450

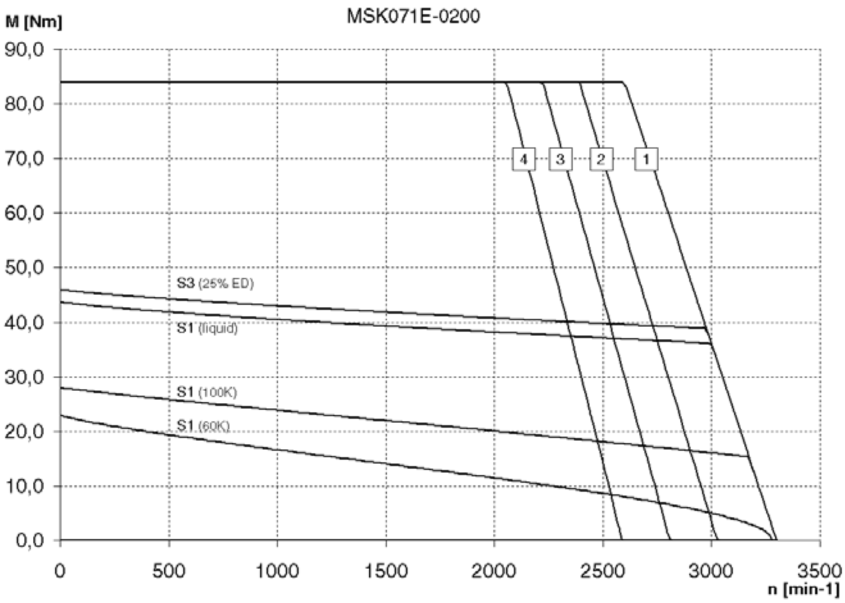
Rexroth Bosch Group

MSK071E Data Sheet

Description	Symbol	Unit	MSK071E-0200	MSK071E-0300	MSK071E-0450
Continuous torque at standstill, 60K	M_{0_60}	Nm	23.0	23.0	23.0
Continuous current at standstill, 60K	$I_{0\_60(eff)}$	A	10.0	12.5	20.0
Continuous torque at standstill, 100K	M_{0_100}	Nm	28.0	28.0	28.0
Continuous current at standstill, 100K	$I_{0\_100(eff)}$	A	12.6	15.2	24.4
Continuous torque at standstill, surface	M_{0_S}	Nm	i.p.	i.p.	i.p.
Continuous current at standstill, surface	$I_{0\_S(eff)}$	A	i.p.	i.p.	i.p.
Continuous torque at standstill, liquid	M_{0_L}	Nm	43.7	43.7	43.7
Continuous current at standstill, liquid	$I_{0\_L(eff)}$	A	19.0	24.9	38.0
Maximum torque	M_{max}	Nm	84.0	84.0	84.0
Maximum current	$I_{max(eff)}$	A	44.9	56.3	90.1
Torque constant at 20°C	K_{M_N}	Nm/A	2.53	2.03	1.29
Constant voltage at 20°C	K_{EMK_1000}	V/ rpm	156.0	126.4	82.7
Winding resistance at 20°C	R_{12}	Ohm	1.16	0.79	0.32
Winding inductivity	L_{12}	mH	9.15	6.2	2.6
Discharge capacitance	C_{ab}	nF	9.5	9.3	9.5
Number of pole pairs	P		4	4	4
Moment of inertia of rotor without brake	J_{rot}	kgm²	0.0029	0.0029	0.0029
Thermal time constant	T_{th}	min	19.8	19.8	19.8
Maximum speed	n_{max}	rpm	4,000	4,500	6,000
Mass	m	kg	23.5	23.5	23.5
Sound pressure level	L_P	dB(A)	< 75		
Ambient temperature during operation	T_{um}	°C	0 to 40		
Setup elevation	h	m	1,000 above MSL		
Degree of protection			IP65		
Insulation class			F (according to EN 60034-1)		

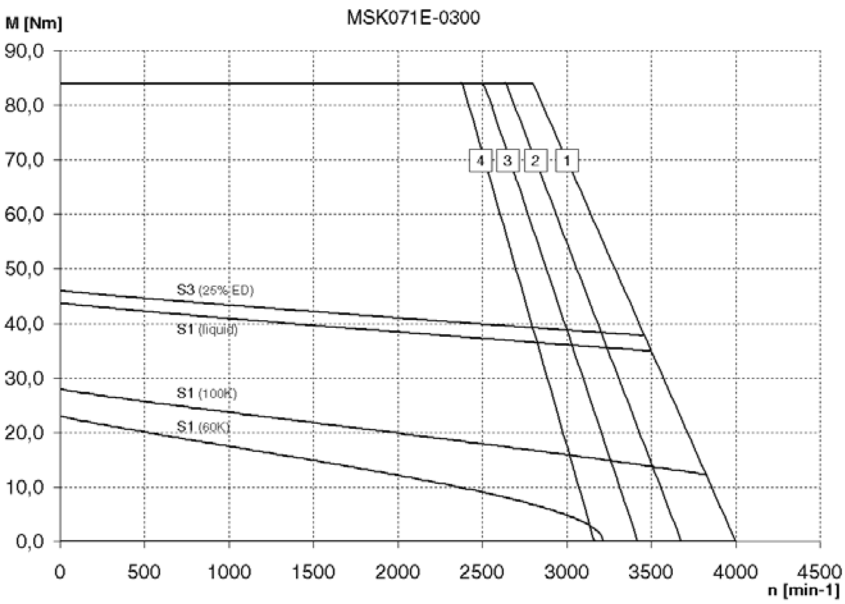
Fig. 4-44: MSK071E Data sheet

MSK071E characteristic curves



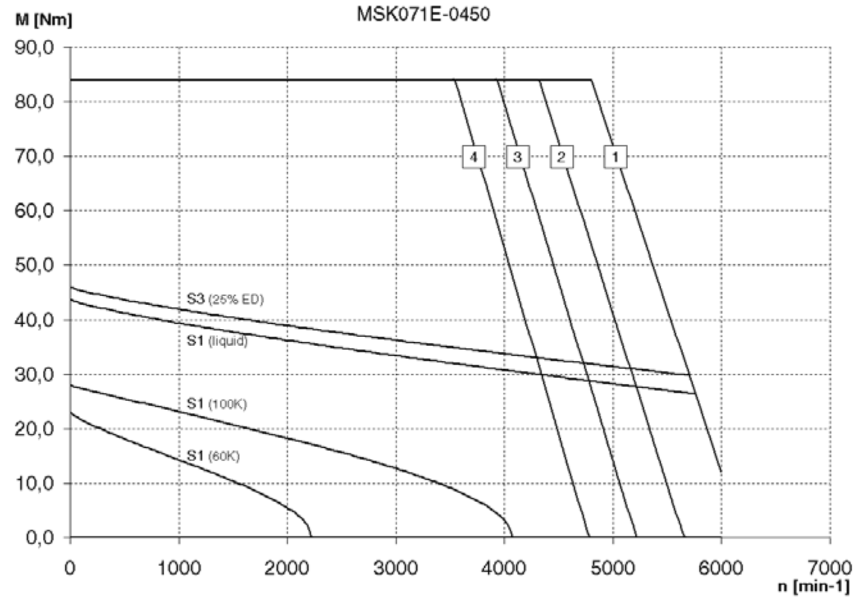
[1]: M_{max} for IndraDrive, controlled feed, 3 x AC 400V
[2]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 480V
[3]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 440V
[4]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 400V

Fig. 4-45: Speed-torque characteristic curve of MSK071E-0200



[1]: M_{max} for IndraDrive, controlled feed, 3 x AC 400V
[2]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 480V
[3]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 440V
[4]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 400V

Fig. 4-46: Speed-torque characteristic curve of MSK071E-0300



[1]: M_{max} for IndraDrive, controlled feed, 3 x AC 400V
[2]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 480V
[3]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 440V
[4]: M_{max} for IndraDrive, uncontrolled feed, 3 x AC 400V

Fig. 4-47: Speed-torque characteristic curve of MSK071E-0450

MSK071 Holding brakes

Description	Symbol	Unit	Holding brake 1 BREMSE 298397	Holding brake 2 BREMSE 308413
Holding torque	M_4	Nm	23	30
Rated voltage (+/- 10%)	U_N	V	24	24
Rated current	I_N	A	0.79	0.94
Connection time	t_1	ms	130	35
Disconnection time	t_2	ms	180	125
Moment of inertia brake	J_{Br}	kgm²	0.00030	0.00030
Mass brake	M_{Br}	kg	1.6	1.6

Fig. 4-48: MSK071 data sheet holding brakes

MSK071 Liquid Cooled

Description	Symbol	Unit	Data	
motor type			MSK071D...	MSK071E...
Nominal power loss	P_{vN}	W	900	1000
Coolant inlet temperature [1)]	ϑ_{ein}	°C	+10 ... +40	
Coolant temperature raise with P_{vN}	$\Delta\vartheta_N$	°C	10	
Minimum necessary required coolant flow for $\Delta\vartheta_N$ [2)]	Q_N	l/min	1,3	1,4
Pressure decrease at Q_N [2)3)]	Δp_N	bar	0,6	0,7
Maximum system pressure	p_{max}	bar	3,0	
Volume liquid cooling duct	V	l	0,05	0,06
pH-value coolant			6 - 8	
Materials with coolant contact			**Description**	
Flange, end shield			Al Mg 5 F32	
Profile			Al Mg Si 0,5 F22	
O-ring			Viton	

1) Notice the combination between coolant inlet temperature and real environmental temperature:
the coolant inlet temperature should be max. 5°C under the real environmental temperature (otherwise danger of condensation exists)!
2) at coolant water
3) for deviating discharge values notice the discharge diagram.

Fig. 4-49: Technical Data liquid coolant for MSK071

MSK071 shaft load

For additional information about permissible radial and axial forces, see the chapter “Application Notes”.

Radial force F_{radial} Diagram for determining the maximum permissible radial force F_{radial}

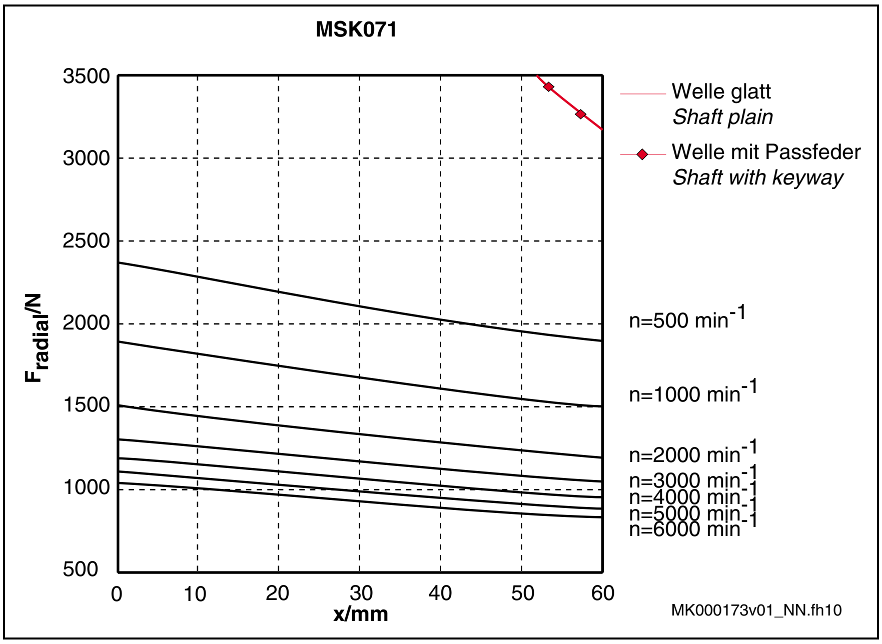


Fig. 4-50: MSK071: permissible radial force (shaft and bearing load)

Axial force F_{axial} The maximum permissible axial force is **500N**.

Rexroth Bosch Group

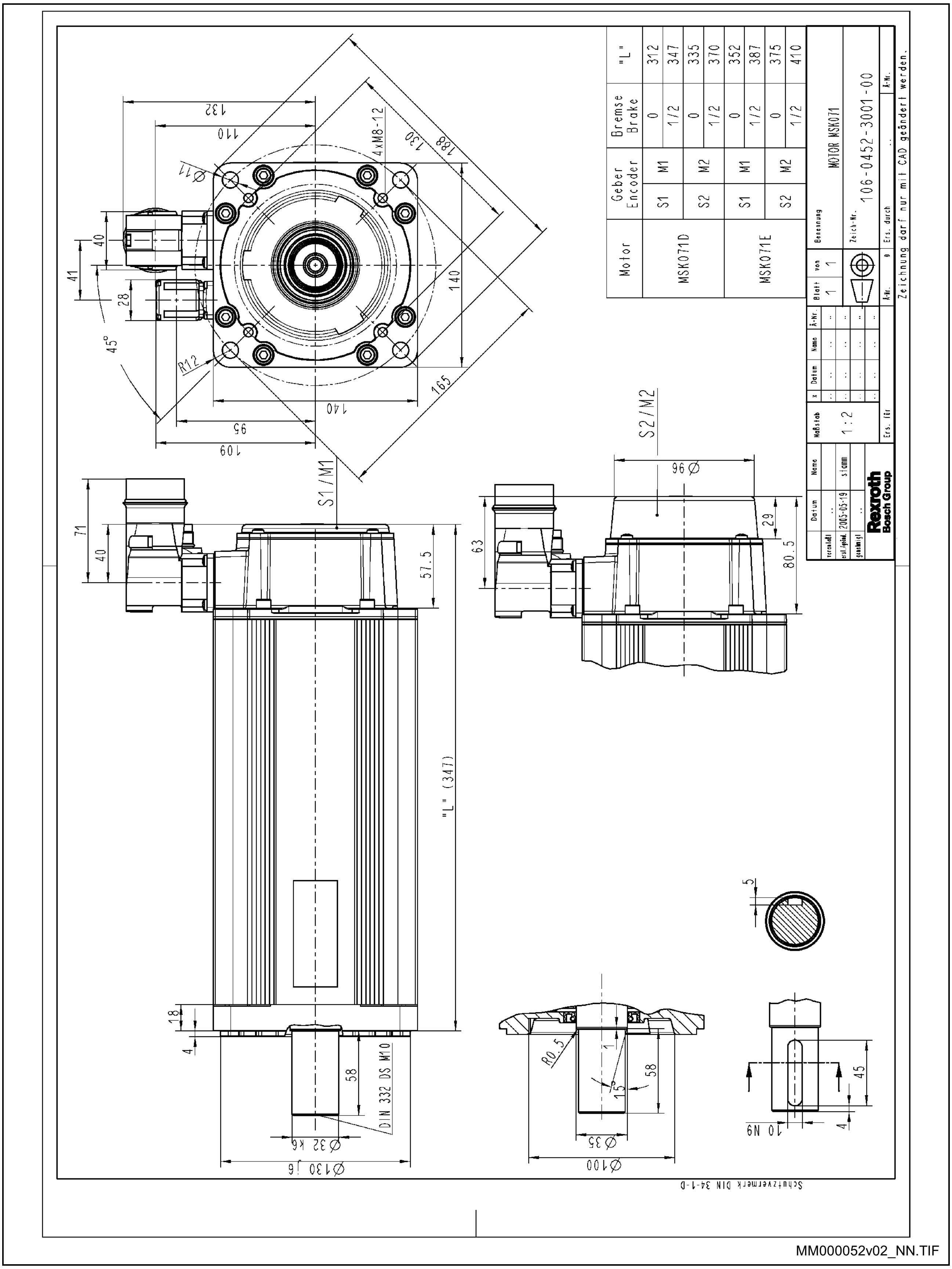
5 Specifications

5.1 Basic Data – Technical Design

<table>
<tr><th>Basic data</th><th colspan="4">Technical design</th></tr>
<tr><td>Motor design</td><td colspan="4">Motor design B5 according to EN60034-7
(for additional information, see section 9.5, Design and Installation Positions)</td></tr>
<tr><td>Housing painting</td><td colspan="4">Black (RAL 9005)</td></tr>
<tr><td>Vibration characteristics</td><td colspan="4">N (normal), according to EN 60034-14</td></tr>
<tr><td>Balance characteristics</td><td colspan="4">G 2.5 acc. to DIN ISO 1940-1</td></tr>
<tr><td rowspan="4">Concentricity, run-out and alignment</td><td colspan="4">According to DIN 42955, edition 12.81 (IEC 60072-1)</td></tr>
<tr><td>Encoder</td><td colspan="2">Concentricity tolerance</td><td colspan="2">Run-out and alignment tolerance</td></tr>
<tr><td>S1, M1</td><td>N</td><td>---</td><td>N</td><td>---</td></tr>
<tr><td>S2, M2</td><td>---</td><td>R</td><td>---</td><td>R</td></tr>
<tr><td>Flange</td><td colspan="4">according to DIN 42948, edition 11.65.</td></tr>
<tr><td rowspan="10">Output shaft, shaft end and centering hole</td><td colspan="4">- plain shaft
– shaft with keyway
motors with keyway are balanced with a complete key. The machine element to be driven must be balanced without a key.
- cylindrical shaft end, according to DIN 748 Part 3, Edition 07.75, IEC 60072 (-1)
- centering hole, according to DIN 332 Part 2, Edition 05.83.</td></tr>
<tr><td>Motor</td><td colspan="2">Corresponding key, according to DIN 6885-A (does not belong to scope of delivery of the motors)</td><td colspan="2">Centering hole, according to DIN 332 Part 2, Edition 05.83</td></tr>
<tr><td>MSK030</td><td colspan="2">3 x 3 x 16</td><td colspan="2">DS M3</td></tr>
<tr><td>MSK040</td><td colspan="2">5 x 5 x 20</td><td colspan="2">DS M5</td></tr>
<tr><td>MSK050</td><td colspan="2">6 x 6 x 32</td><td colspan="2">DS M6</td></tr>
<tr><td>MSK060</td><td colspan="2">8 x 7 x 40</td><td colspan="2">DS M8</td></tr>
<tr><td>MSK070</td><td colspan="2">10 x 8 x 45</td><td colspan="2">DS M10</td></tr>
<tr><td>MSK071</td><td colspan="2">10 x 8 x 45</td><td colspan="2">DS M10</td></tr>
<tr><td>MSK100</td><td colspan="2">10 x 8 x 45</td><td colspan="2">DS M10</td></tr>
<tr><td>MSK101</td><td colspan="2">10 x 8 x 70</td><td colspan="2">DS M12</td></tr>
<tr><td></td><td colspan="4">For more information about drive shafts, see section 9.6, “Output Shaft”</td></tr>
</table>

Fig. 5-1: IndraDyn S basic data

5.7 Frame Size MSK071



MM000052v02_NN.TIF

Fig. 5-7: MSK071...NN specification

5.8 Frame Size MSK071 with liquid coolant

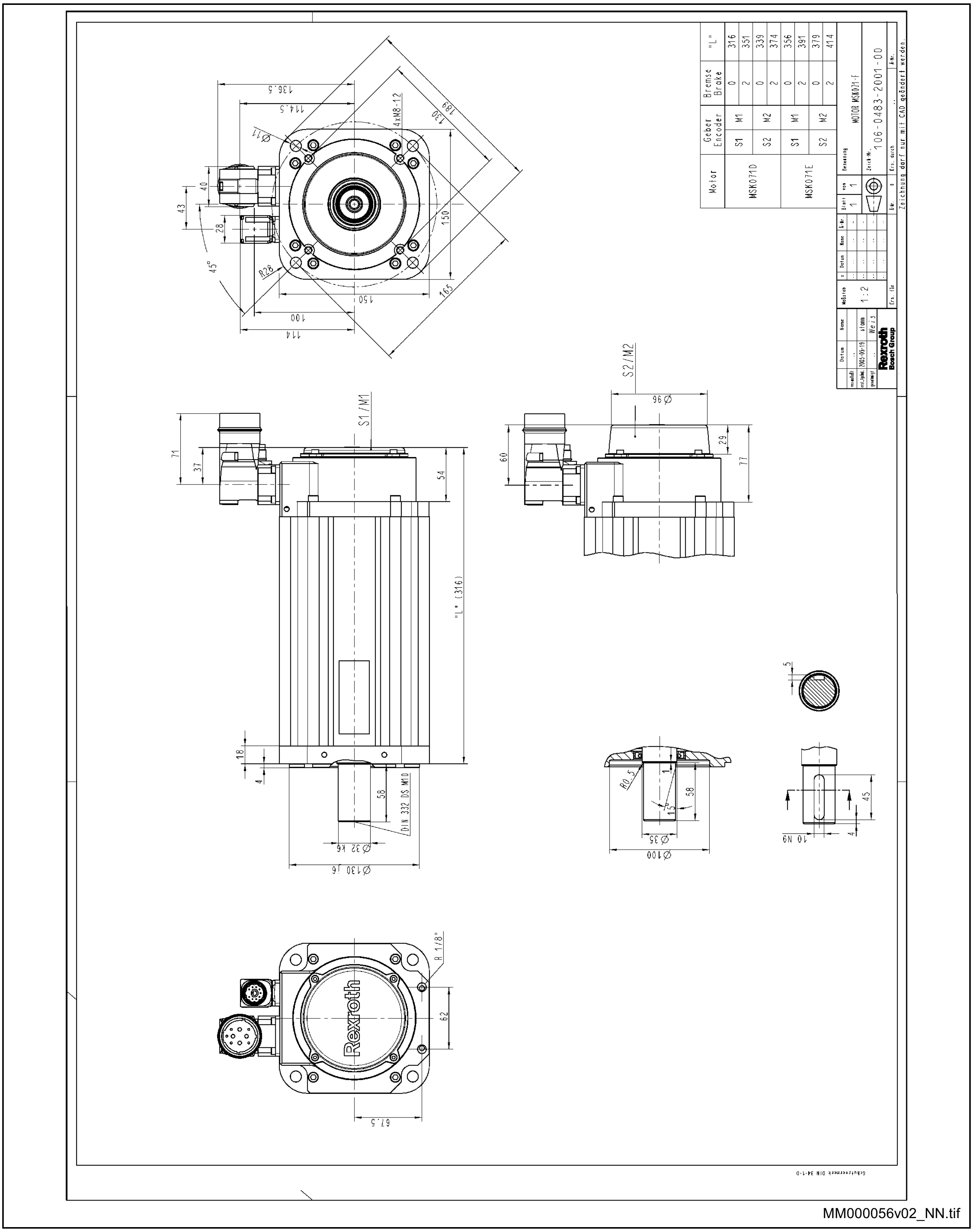


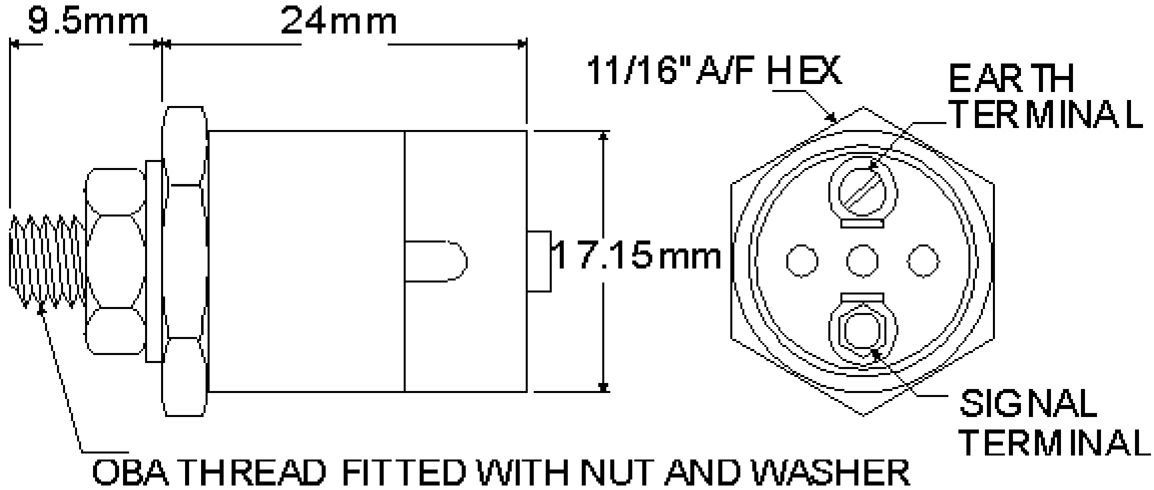
Fig. 5-8: MSK071...FN specification

VP7

VP7 Accelerometer

- Low Cost
- High Sensitivity
- Soldered Connections

Dimensions



VP7 Accelerometer

Features

The VP7 is a rugged low cost piezo electric accelerometer offering the advantage of a very high voltage sensitivity. An integral stud and solder terminal connections allow for reliable low cost OEM installation.

The VP7 works well with modern low noise FET input amplifiers in applications where analysis or an indication of very low levels of vibration is required.

Technical Specification

Complete instrument		**min**	**max**	**units**
Voltage sensitivity	@ 40 Hz, 120pF load	80	125	mV/g
Capacitance		340	500	pF
Mounted resonance		15		KHz
Transverse sensitivity			10	%
Operating Temperature		-40	+80	°C
Maximum acceleration	operate	-100	+100	g pk
Weight		40	50	gm
Mounting	Integral OBA stud			
Mounting torque	Recommended		1	N/m
	Maximum		2	N/m
Connections	Solder tag			
Case material	Brass, chrome plated			

All performance data applies at 20 ± 5 °C.

Operation at maximum ratings for extended periods may affect reliability.

The VP7 accelerometer includes features, which are the subject of worldwide patents or patent applications and/or other intellectual property.

About Lamerholm Electronics Ltd.

Lamerholm Electronics, develops, manufactures and markets a broad range of shock, environmental, temperature monitoring and damage prevention products. The companies' worldwide distribution network is coordinated from the UK base, at:

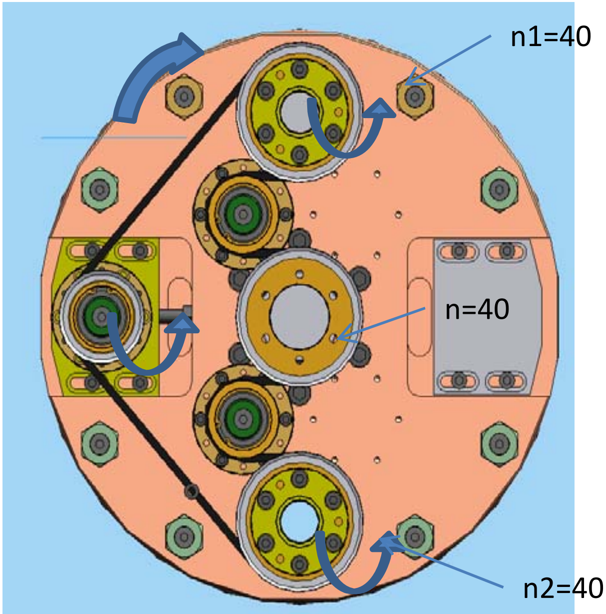
The Pixmore Centre
Pixmore Avenue
Letchworth
Herts, SG6 1JG

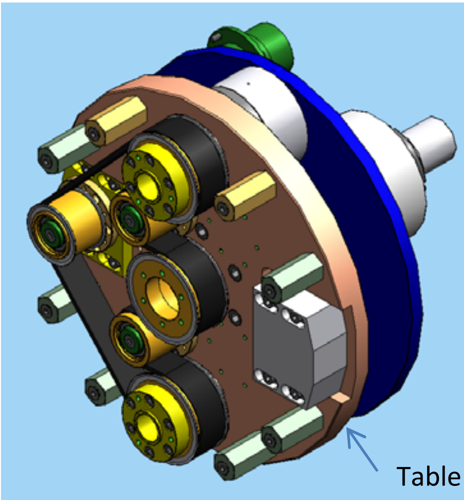
Tel: +44 (0) 1462 481396
Fax: +44 (0) 1462 473942
Email: sales@shocklog.com
Web: www.shocklog.com

Your ShockLog Representative:

Lamerholm Electronics

Input	MSK071E-300	
Line Speed	1000	ppm
UP	2	
Table Speed	500	rpm
Pulley Speed	500	rpm





Pulley specs.

Reductor pulley	30
Guided pulley	90
Reduction ratio	3
Pulley velocity ratio	1

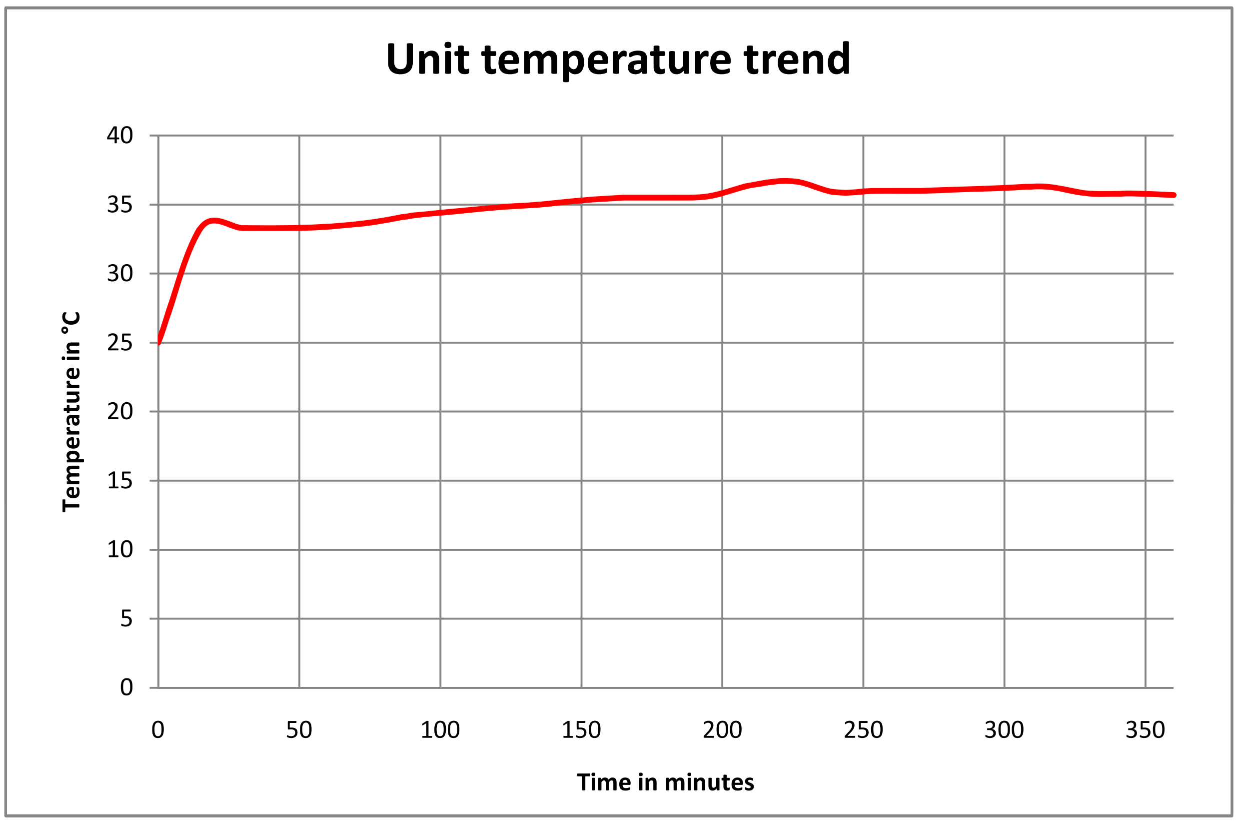
Motor specs.

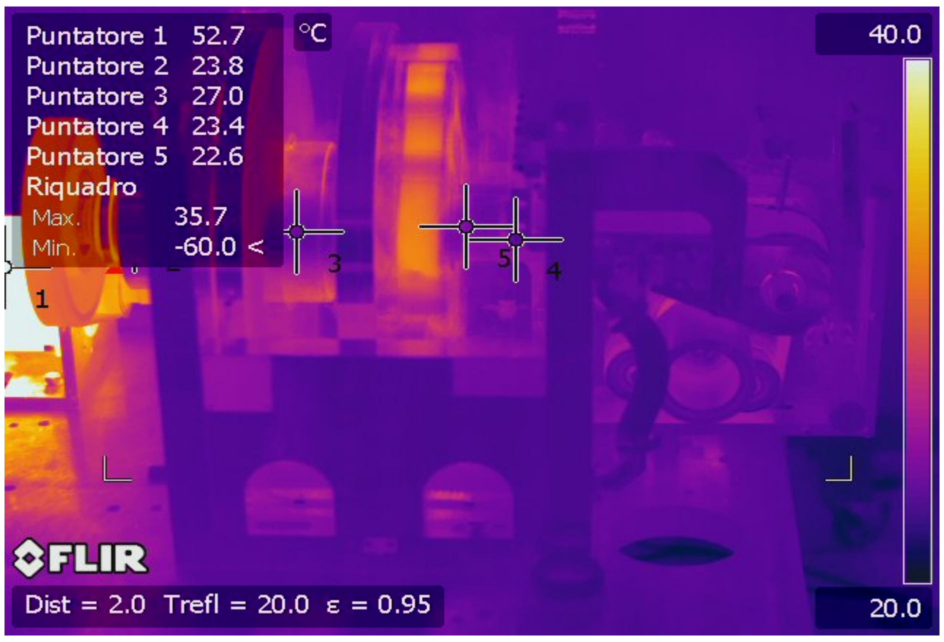
Moment of inertia of rotor without brake	0,011	kgm^2
Maxium torque	84	Nm
Maxium speed	3000	rpm
Table	18906271	gcm^2
Equivalent inertia	1,8906271	kgm^2
(Calculed by Solid Edge)		
Reduced inertia	0,2100697	
Cutter (x2)	214496,07	gcm^2
Equivalent inertia	0,0214496	kgm^2
(Calculed by Solid Edge)		
Reduced Inertia	0,0023833	kgm^2
All		
Equivalent inertia	1,9335263	kgm^2
Reduced inertia	0,2148363	kgm^2
Inertia check		
Inertia ratio	19,530569	
Inferior than	80	

Analysis Dry Run 1000 pm - Disposible tape unit 30-11-10

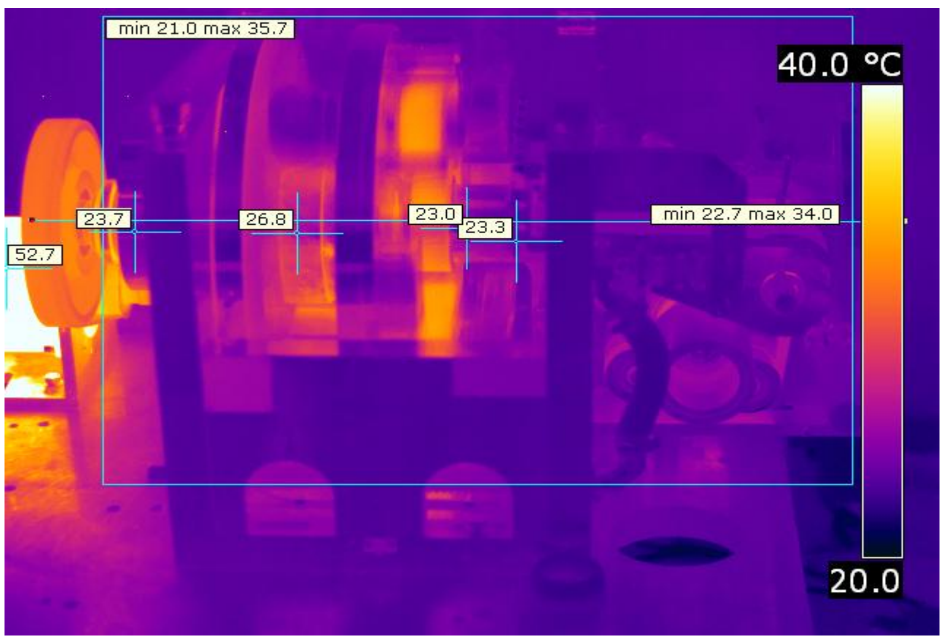
Termical trend analysis for 5 hours at 1000ppm

Tempo	damento temperature su moto
0	25
15	33,3
30	33,3
45	33,3
60	33,4
75	33,7
90	34,2
105	34,5
120	34,8
135	35
150	35,3
165	35,5
180	35,5
195	35,6
210	36,4
225	36,7
240	35,9
255	36
270	36
285	36,1
300	36,2
315	36,3
330	35,8
345	35,8
360	35,7





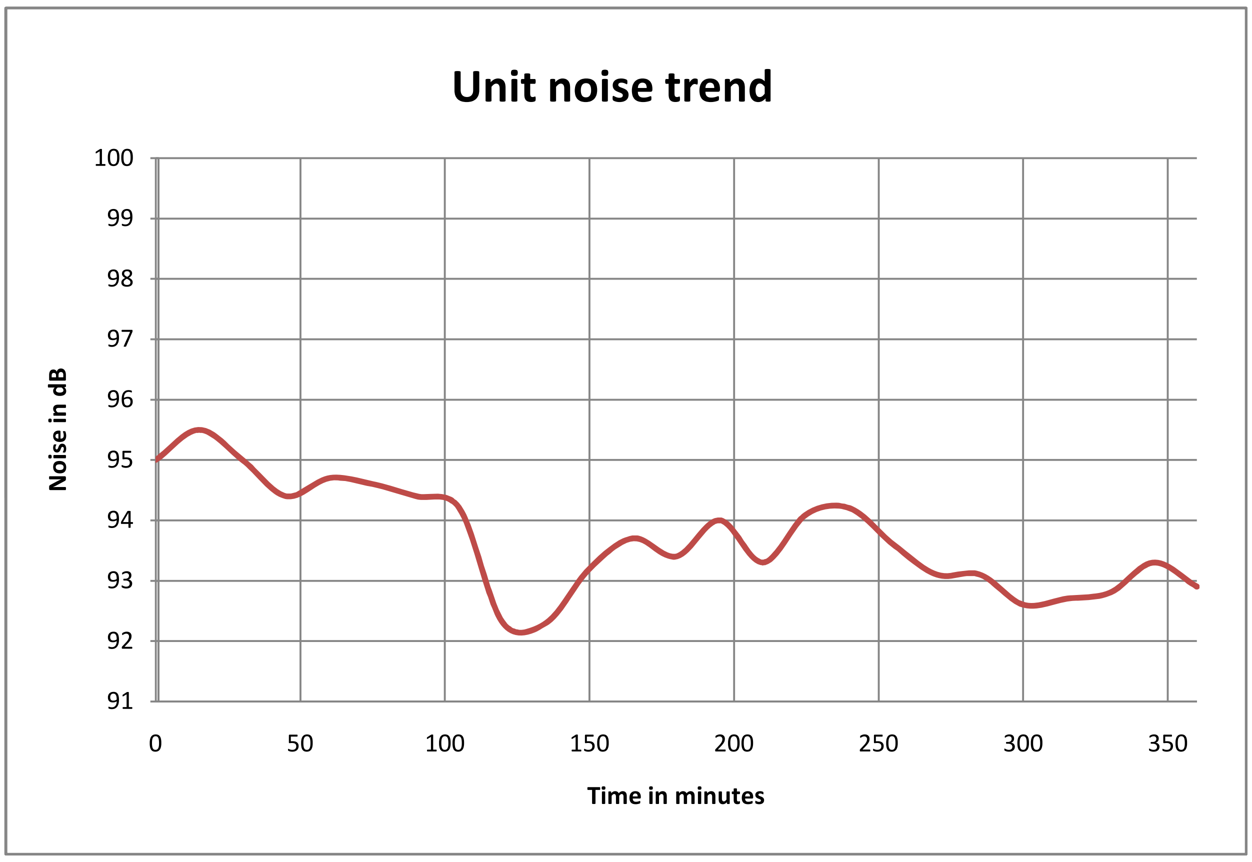
The temperature of the critical points of the cutting zone is 35°C in the stacionary period of working



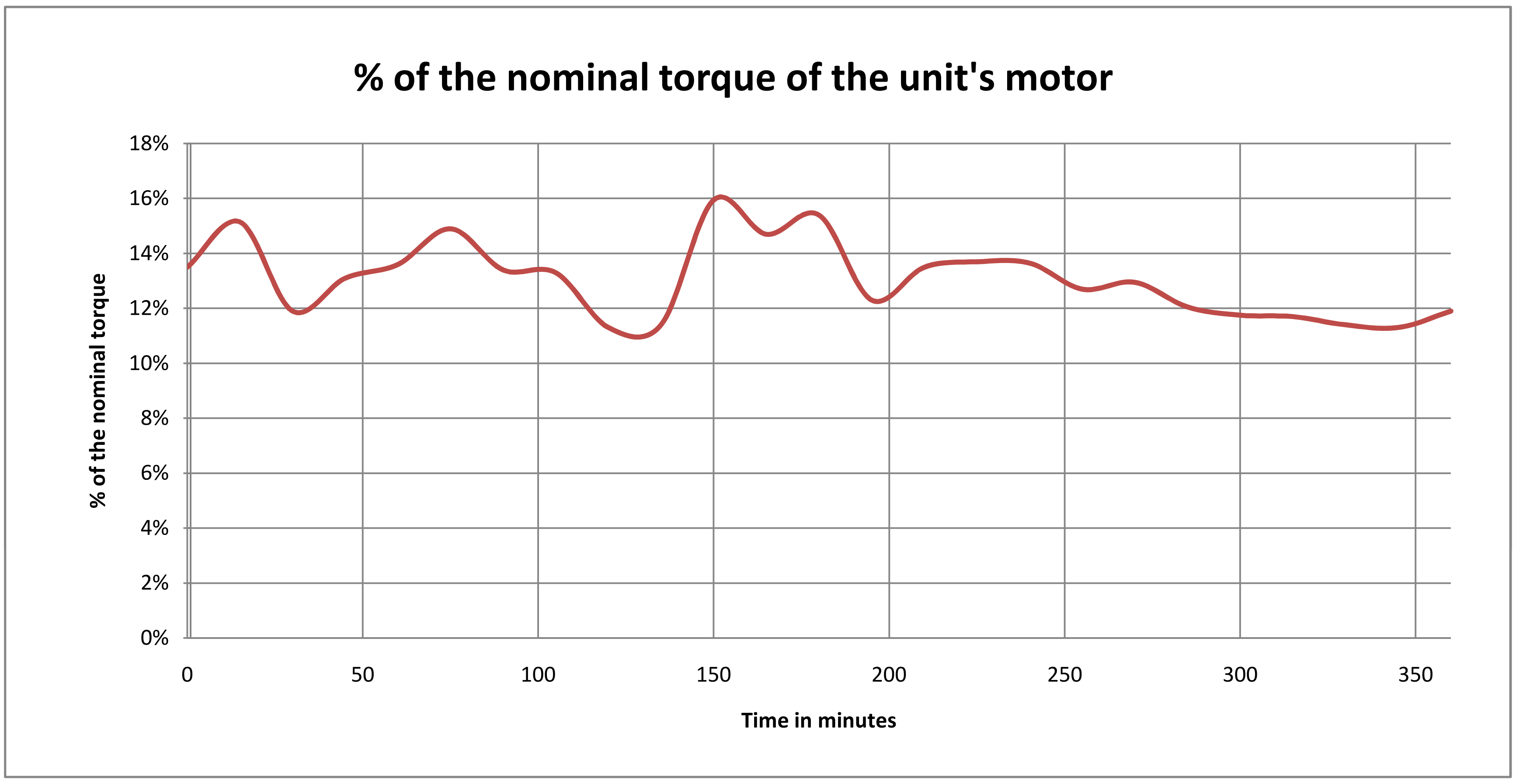
As we can see in the image, our temperature in the critical points and in the critical line is very lower than the maximum allowed by the bearings, 60°C-70°C

Maximum noise trend analysis for 5 hours at 1000 ppm

Tempo	ɫamento temperature su motoı
0	95
15	95,5
30	95
45	94,4
60	94,7
75	94,6
90	94,4
105	94,2
120	92,3
135	92,3
150	93,2
165	93,7
180	93,4
195	94
210	93,3
225	94,1
240	94,2
255	93,6
270	93,1
285	93,1
300	92,6
315	92,7
330	92,8
345	93,3
360	92,9



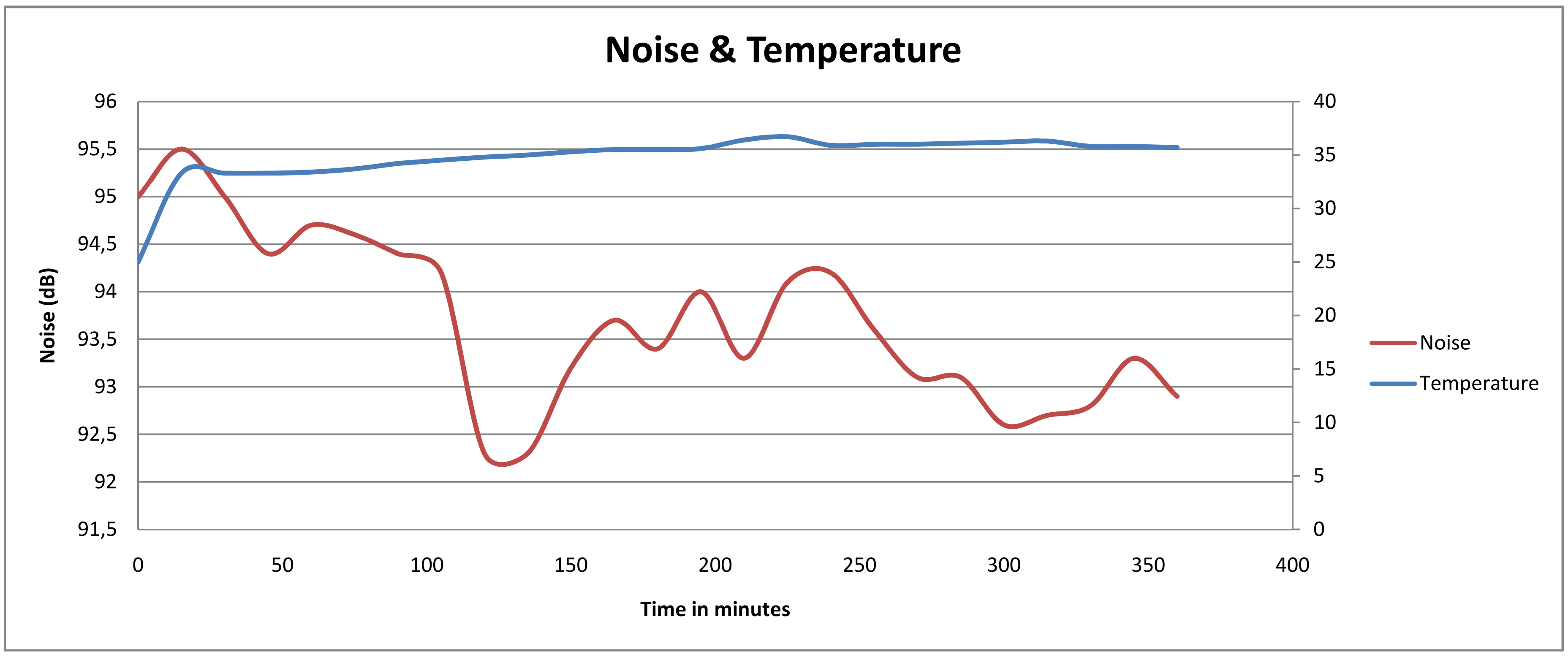
In the unit's stacionary behaviour we measure in media 93 dB of noise, and the maximum admissible value is 90 dB with "carteratura", but we are without it, whit it this value will downgrade till 83-85 dB, we are in the limits

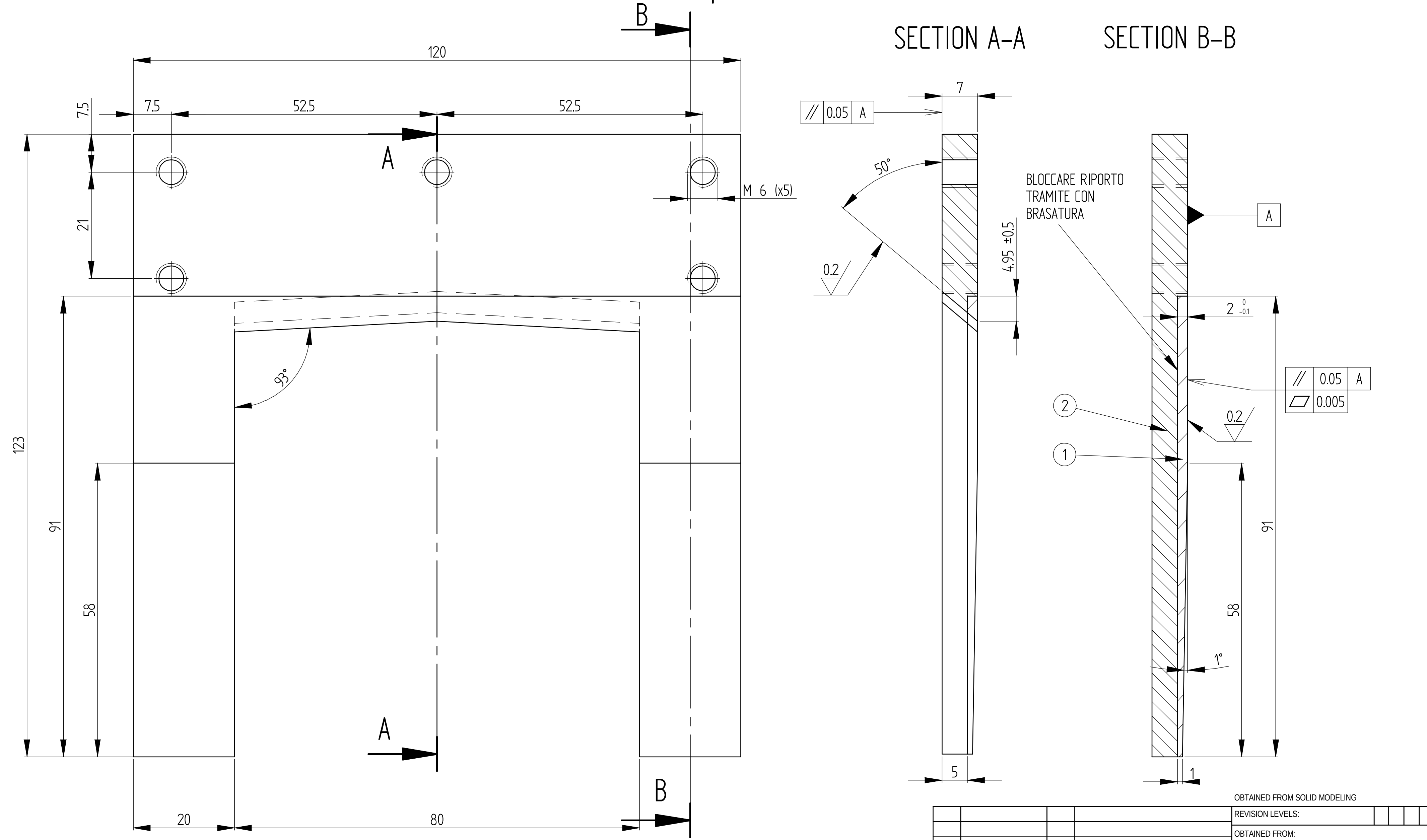


The % of the nominal torque used in this application is enough lower to validate the use of this motor in that application

% of the nominal torque of the motor unit at 1000ppm for 5 hours

Tempo	emperature
0	13,50%
15	15,15%
30	11,90%
45	13,10%
60	13,60%
75	14,90%
90	13,40%
105	13,30%
120	11,30%
135	11,40%
150	15,95%
165	14,70%
180	15,40%
195	12,30%
210	13,50%
225	13,70%
240	13,65%
255	12,70%
270	12,95%
285	12,05%
300	11,75%
315	11,70%
330	11,40%
345	11,30%
360	11,90%


Noise & Temperature
Noise (dB)
96
95,5
95
94,5
94
93,5
93
92,5
92
91,5
40
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
350
400
Time in minutes
Noise
Temperature



1 TUNGSTEN CARBIDE (85% - 87%)
COBALT (13% - 15%)
HARDNESS (MINIMUM)89,5 ROCKWELL-A
DENSITY (MINIMUM) 14G/CM3
TRANSVERSE RUPTURE STRENGHT 350.000 PSI
GRAIN SIZE RANGE SUBMICRON TO (2) MICRON
HOT ISOSTATIC PRESS (KIP)

2 MATERIAL CODE: 7039510
TONDO LAM. 39NICRMO3 D110 BON.

OBTAINED FROM SOLID MODELING

REVISION LEVELS:

OBTAINED FROM:

FOR ALL TOLERANCES NOT EXPRESSELY SPECIFIED REFER TO:
UNI EN 22768 (ISO 2768) MEDIUM PRECISION VALUES.
ROUGHNESS SIMBOL ACCORDING TO DIN ISO 1302

ID.	MATERIAL CODE	QUANTITY	DESCRIPTION

DATE	DRAWN-BY	CHECKED-BY	UNDIMENSIONED CHAMFERS

HEAT/SURFACE TREATMENT

ROUGHNESS

FAMECCANICA.DATA S.p.A.
Sambuceto di S. Giovanni Teatino (CH) ITALY

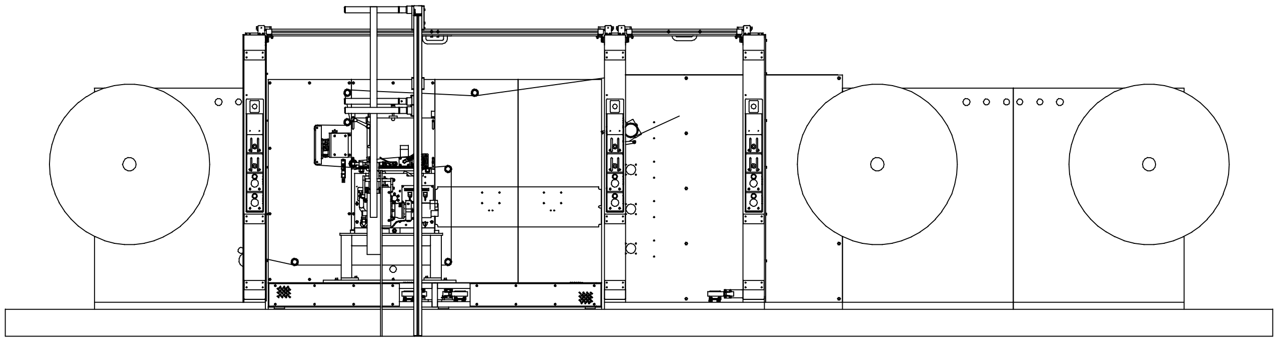
ITALIAN DESCRIPTION

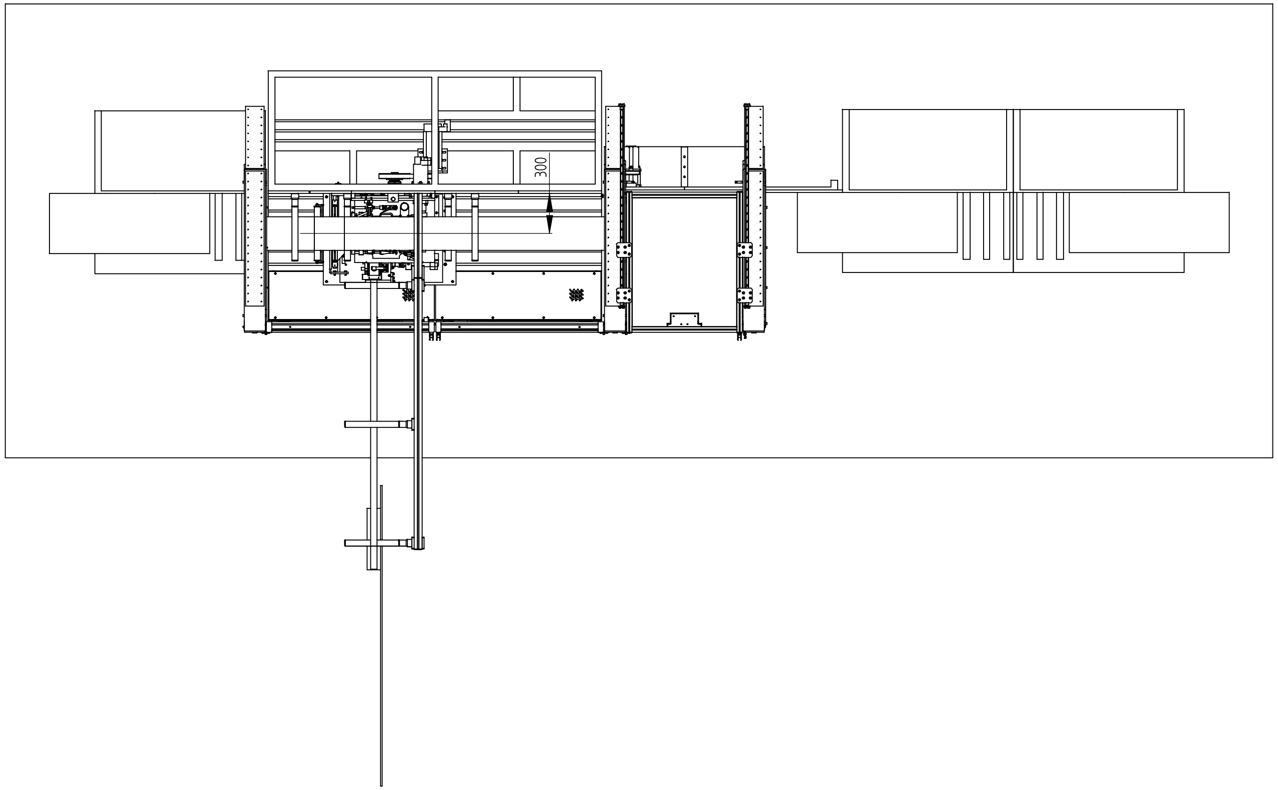
SHEET /

ENGLISH DESCRIPTION

SCALE

DRAWING NUMBER /





OBTAINED FROM SOLID MODELING

ID.	MATERIAL CODE	QUANTITY	DESCRIPTION

DATE	DRAWN-BY	CHECKED-BY	UNDIMENSIONED CHAMFERS

HEAT/SURFACE TREATMENT

ROUGHNESS

ITALIAN DESCRIPTION

ENGLISH DESCRIPTION

REVISION LEVELS:

OBTAINED FROM:

FOR ALL TOLERANCES NOT EXPRESSELY SPECIFIED REFER TO:
UNI EN 22768 (ISO 2768) MEDIUM PRECISION VALUES.
ROUGHNESS SIMBOL ACCORDING TO DIN ISO 1302

FAMECCANICA.DATA S.p.A.
Sambuceto di S. Giovanni Teatino (CH) ITALY

SHEET /

SCALE

DRAWING NUMBER /